66th Congress, 3d Session : : : : : : : : : : : : : House Document No. 1048

U. S. DEPARTMENT OF AGRICULTURE

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1920

PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS
STATES RELATIONS SERVICE

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A. C. True, Director.

OFFICE OF EXPERIMENT STATIONS.

E. W. Allen, Chief.

RELATIONS WITH INSTITUTIONS FOR AGRICULTURAL RESEARCH.

Supervision of Work and Expenditures of the State Experiment Stations Under Federal Appropriations.

E. W. Allen, E. R. Flint, J. I. Schulte, W. H. Evans, W. H. Beal.

Experiment Station Record.

E. W. Allen, Ph. D., editor; H. L. Knight, B. S., associate editor; Sybil L. Smith, M. A., agricultural chemistry and agrotechny; W. H. Beal, A. B., M. E., and R. W. Trullinger, B. S. C. E., meteorology, soils, and fertilizers; W. H. Evans, Ph. D., and W. E. Boyd, Ph. B., agricultural botany, bacteriology, and plant pathology; H. M. Steece, B. S., field crops; J. W. Wellington, B. S., horticulture and forestry; W. A. Hooker, B. S., D. V. M., economic zoology and entomology; C. F. Langworthy, Ph. D., D. Sc., and Sybil L. Smith, M. A., foods and human nutrition; F. J. Kelley, B. S., animal husbandry, dairying, and dairy farming; W. A. Hooker, B. S., D. V. M., and Sybil L. Smith, M. A., veterinary medicine; R. W. Trullinger, B. S. C. E., rural engineering; Eugene Merritt, A. B., and Louise Marbut, A. B., rural economics; E. H. Shinn, A. B., B. S., and Marie T. Spethmann, agricultural education; Martha C. Gundlach, A. B., indexing; William Henry, proof reading.

DIVISION OF INSULAR STATIONS.

W. H. Evans, Ph. D., Chief.

Alaska Experiment Stations.

C. C. Georgeson, M. S., D. Sc., agronomist in charge, Sitka; M. D. Snodgrass, B. S., assistant in charge, Fairbanks; G. W. Gasser, B. S., assistant in charge, Rampart; F. E. Rader, B. S., assistant in charge, Matanuska; M. T. White, B. S., assistant in charge, Kodiak.

Guam Experiment Station.

C. W. Edwards, B. S., animal husbandman in charge, Island of Guam; Glen Briggs, B. S., agronomist and horticulturist; W. J. Greene, B. S., assistant in agronomy and extension work; J. Guerrero, assistant in horticulture; Peter Nelson, assistant.

Hawaii Experiment Station.

J. M. Westgate, M. S., agronomist in charge, Honolulu; W. T. Pope, M. S., horticulturist; Wallace Macfarlane, specialist in soil investigations; F. G. Krauss, superintendent of extenison work, Haiku; R. A. Goff, B. S., extension agent, Hilo; C. W. Carpenter, M. S., plant pathologist; H. L. Chung, M. S., agronomist; J. C. Ripperton, assistant chemist.

Porto Rico Experiment Station.

D. W. May, M. Agr., agronomist in charge, Mayaguez; T. B. McClelland, A. B., horticulturist; W. V. Tower, B. S., entomologist; L. G. Willis, B. S., chemist; Thomas Bregger, B. S., plant breeder; J. O. Carrero, B. S. Ch. E., assistant chemist; W. P. Snyder, B. S., assistant in plant breeding; H. C. Henricksen, B. Agr., specialist in farm management, San Juan; J. A. Saldana, assistant in horticulture.

Virgin Islands Experiment Station.

Longfield Smith, Ph. D., agronomist in charge, St. Croix; C. E. Wilson, M. A., entomologist.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
States Relations Service,
Washington, D. C., March 20, 1922.

Sir: I have the honor to transmit herewith a report on the agricultural experiment stations in the United States for the fiscal year ended June 30, 1920. This is a part of a report prepared in accordance with the following provision of the act of Congress of March 4, 1915, entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and sixteen":

That hereafter there be prepared by the Department of Agriculture an annual report on the work and expenditures of the agricultural experiment stations established under the act of Congress of March second, eighteen hundred and eighty-seven (Twenty-fourth Statutes at Large, page four hundred and forty), on the work and expenditures of the Department of Agriculture in connection therewith, and on the cooperative agricultural extension work and expenditures of the Department of Agriculture and of agricultural colleges under the act of May eighth, nineteen hundred and fourteen, entitled "An act to provide for cooperative agricultural extension work between the agricultural colleges in the several States receiving the benefits of an act of Congress approved July second, eighteen hundred and sixty-two, and of acts supplementary thereto, and the United States Department of Agriculture"; and that there be printed annually eight thousand copies of said report, of which one thousand copies shall be for the use of the Senate, two thousand copies for the use of the House of Representatives, and five thousand copies for the use of the Department of Agriculture (38 Stat. L., p. 1110).

This report embodies the information heretofore submitted in compliance with the provisions of 34 Statutes at Large, page 64, section 5.

Very respectfully,

A. C. True, *Director.*

Hon. Henry C. Wallace,
Secretary of Agriculture.

CONTENTS.

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1920.

By E. W. Allen, E. R. Flint, and J. I. Schulte.

GENERAL CONDITIONS.

The year 1920 brought little relief to the agricultural experiment stations. It continued to be a critical period for them in attempting to maintain their activities under unusual costs on a pre-war revenue. They are the last branch to recover from the effects of the war period.

While the total income of the stations showed a small aggregate increase, its purchasing power fell off very materially. In many cases there was no increase in State support, and in a few instances there was an actual decrease. The result was a serious curtailment of the lines of investigation, and inability to take up many questions upon which there is demand for information.

The demands for scientifically trained men in commercial lines and the better salaries which such opportunities offer has alarmingly depleted the station staff in many cases, and these vacancies have been difficult to fill, owing to the lack of men specially trained for such service. Station salaries, in many instances, have not paralleled salaries of heads of departments in the colleges and universities with which the stations are connected, which discrimination has proved a source of dissatisfaction. The lack of funds and men has affected the colleges as well as the stations, resulting in a tendency to utilize more and more the station force for teaching purposes to the detriment of the investigational work. In some instances not only are members of the station staff called upon to teach, but they have taken considerable part in extension activities.

With decreased purchasing power of the funds available, it has become difficult not only to purchase necessary new apparatus, equipment, and live stock, but in some cases the replacement and prevention of deterioration of the present equipment has become a serious problem. Many of the stations, with the increasing demands for information, are finding themselves restricted for land, a condition which is aggravated by the fact that real estate in the vicinity of such institutions has risen very much in price and is now difficult or impossible to obtain.

To some extent these factors are a part of the very general conditions which have affected the country as a whole as a result of the war, and as these assume a more normal state will probably be more or less corrected. In fact the indications are that the most critical stage has been passed, but the position in which the stations now find themselves calls not only for most careful administration, but for sympathetic understanding and appreciation on the part of those responsible for the general policy of development.

From the nature of the work, the station has, in a measure, been overshadowed in the popular mind by those activities which come into more personal contact with the farmer and the general public; and unless means are devised for giving greater publicity to the importance of the station and its adequate support, the present serious condition may be slow in being properly remedied. Research is basic to success in teaching and extension, and continued neglect of it, while drawing on the results of the past, will soon make itself felt in the other lines of effort. Indeed, this is already the case to some extent.

STATION FUNDS.

The income of the stations for the year (excluding the insular stations) was derived from the Federal appropriations under the Hatch and Adams Acts amounting to $1,440,000, and State appropriations of about $3,500,000, not including sales funds, balances, specific appropriations for regulatory functions, etc. The details of the receipts and expenditures of the several stations are given on pages 88–94.

A brief summary of the resources of the stations, in addition to the Hatch and Adams funds, is given here.

The Alabama Legislature appropriated $5,000 for the station at Auburn, this being the first time in its history that it has received State aid. The local experiment fund of $27,000 was continued. The total State appropriation for the Arizona station was about $73,171, most of it for specific purposes, with sales of $25,377. The State aid for the Arkansas station was approximately $18,896, the sales being $7,500.

The California station received $150,000, or about one-fourth of the appropriation to the college of agriculture, and in addition a special appropriation for investigations on deciduous fruits of $50,000, and $20,000 for the citrus station at Riverside.

The total amount received by the Colorado station, exclusive of the Federal funds, was $91,440, $61,892 of this being from the State mill levy. The Connecticut State station receives only half of the Federal funds, with State maintenance amounting to $35,000 annu-

ally, the balance of the Federal funds going to the Storrs station, which receives also $12,625 from the State.

The State funds for the Delaware station amounted to $10,000 annually. The Florida station received $5,000 and the Georgia station $8,000.

The total State appropriation for the Idaho station was $27,150, and the Illinois station received State support amounting to $195,500. The receipts of the Indiana station, other than Federal, were $75,000 appropriated for maintenance of the station, with $117,966 from the feeding-stuffs and fertilizer control, a special swine-disease fund of $15,000, the creamery-license and stallion-enrollment fund of $24,772, the experiment-orchard fund of $1,600, and the Moses Fell Annex fund of $22,297.

The Iowa station received $134,750 for support and $88,961 for soil survey. The State appropriation for the Kansas station was $93,800. The funds used specifically for experiment and research at the Kentucky station were $50,000 direct State appropriations, the use of the feeding-stuffs and fertilizer fees up to $44,000, and $20,000 of the sales fund.

The income of the Louisiana station included $26,541 of State funds and $18,115 from sales. The State appropriations for the Maine station are $5,000 for the Highmoor farm, $5,000 for the Aroostook farm, and $5,000 for animal husbandry investigations. The Maryland station receives $27,576 from the State, with an additional sum of $6,608 for the Ridgely farm and $22,030 from sales. The Massachusetts State appropriation for the station for the year was $55,875, with an additional sum of $18,632 from fees, sales, and miscellaneous sources.

The total income of the Michigan station, exclusive of Federal funds, was $139,700, which included $779 for the South Haven station, $8,624 for the Upper Peninsular station, receipts from the fertilizer and feeding-stuffs control, and miscellaneous. The total State receipts of the Minnesota station were $371,272, of which $257,173 was direct appropriation and $82,843 from sales. Of this, $242,238 was used at the central station, the balance going to five substations. The last Legislature of Mississippi made appropriations totaling $46,300 for the biennium, for the central station, for specific purposes, including farm management, horticulture, poultry, dairy, plant diseases, purchase of live stock, and for printing bulletins. The Missouri station received $18,035 from the State, $16,204 from sales, $38,972 from the fertilizer control, with additional special appropriations of $10,900 for farm crops and $8,988 for soil survey. The Montana Legislature appropriated $110,500 for the station and branch stations, which also had a sales fund of $27,342.

The Nebraska station received approximately $90,540 from the State and sales. The North Platte substation expended about $60,000, the Scotts Bluff substation $8,000, and the Valentine substation $10,000. The Nevada station receives no State funds, and the sales amounted to only $320. The New Hampshire station also received no State support, but had sales and miscellaneous funds amounting to about $17,000.

The total State appropriation for the New Jersey station was about $227,000, most of it for specific purposes and departments, not all of a research nature, as the egg-laying contest, mosquito control, etc. State appropriations for the New Mexico station were $7,500, supplemented by a sales fund of $6,323. The New York Cornell station receives from the State $109,022; from fees, $12,420; from sales, $14,837; and from miscellaneous sources, $2,897. The New York State station receives an appropriation of $146,196. The North Carolina station had the use of $112,150 of funds from the State department of agriculture for experimental work.

The total income of the central and branch stations in North Dakota, exclusive of Federal funds, was about $150,000, besides $6,000 from the Flax Development Committee for flax investigations and $850 from the Durum Milling Association. The total sales funds were $58,187.

The Ohio station received $279,035 from the State, specifically appropriated, supplemented with a sales fund of $56,675. The State appropriations for the Oklahoma station were $10,000, being a $5,000 increase over previous years, with an additional fund from sales of $5,000. The income of the Oregon station from the State is $86,500, supplemented by $2,000 from local communities and a sales fund of $18,533. The State fund is rather specifically appropriated.

The Pennsylvania station received a biennial State appropriation of $6,000 for tobacco investigations. A part of the general State appropriation to the school of agriculture, supplemented by the receipts from sales, is used for research.

The Rhode Island station receives no State aid, with the exception of $2,000 that was to be used for increasing salaries of the station staff. The South Carolina station also receives no State support, but an appropriation of $25,000 was made for the substations, for starting a beef-cattle investigation, and for cooperative fertilizer experiments. About $9,500 is received from Clemson College and the sales funds amount to about $3,000. The only State aid for the South Dakota station is a printing fund of $1,500, with a sales fund of about $4,500. The State appropriates $13,500 for the branch stations. The total State income for the Tennessee station, including the branch stations, is about $52,000, with a sales fund of about $16,000. The Texas station receives a total of $213,540 from the

State, including $6,000 for experimental apiaries. The sales fund at the central station is about $14,960 and at the branch stations $62,650.

In Utah the State appropriated $100,000 for the biennium for the station. Davis County contributes $1,000 per year and furnishes the land for an experimental farm in the county, and Uintah County contributes $2,500 for a soil survey of that county. The sales fund at this station was about $19,500. The Vermont Station receives no State appropriation.

The direct State appropriation for the Virginia station was $39,450, with sales and miscellaneous receipts amounting to about $22,000. The Washington station, exclusive of the branch stations, received $50,000 from the State, and $43,043 from sales. The receipts at the West Virginia station were $45,000 from the State for maintenance, $15,000 for buildings and improvements at the central station, $7,500 for buildings at the Reymann memorial farms, and a sales fund of $21,940.

The expenditures from State funds at the Wisconsin station were $162,527. The Wyoming station receives $10,000 for experimental purposes, with $20,000 for the branch stations and a sales fund of about $4,400.

Twelve stations receive over $100,000, exclusive of Federal funds, as follows: Ohio $279,035, Minnesota $257,173, Iowa $222,750, Texas $213,540, Illinois $195,500, California $149,085, New York State station $146,195, North Carolina $112,150, Montana $110,517, New York Cornell station $109,022, Michigan $104,870, and Nebraska $101,703. Five stations receive some State aid, but less than $10,000, and six stations receive no direct State support.

CHANGES IN PERSONNEL.

Changes in personnel continued to be large, due to the same causes as were mentioned last year, namely, low salaries and more opportunities in commercial lines. Where this involves heads of departments, as it has in many instances, it invariably causes more or less disruption in the investigational work of the station, resulting often in the abandonment of projects that are in progress.

A certain amount of change, involving the advancement of assistants to better and more responsible positions after sufficient experience has been secured is of course legitimate and to be encouraged, but every effort should be made to retain those members of the staff in charge of the project work. During the year there was a change in the directorship of seven stations, including those of Arkansas, California, Delaware, Indiana, Louisiana, Massachusetts, and Oregon. This is a comparatively large number. Over fifty heads of departments resigned, with increasing numbers through the grades of asso-

ciates and assistants, the total changes in some stations amounting to over fifty.

Another serious aspect of this situation was the difficulty in securing men to fill the positions vacated, especially with candidates who are familiar with the local conditions in the State where they occur, which is often advantageous. This emphasizes the apparent lack of men who are training themselves for research work.

A mitigation at least of this constant large change in personnel will come when the stations can offer more adequate salaries, which is gradually being accomplished, and further improvement may be looked for when the station, as the research branch of the institution with which it is connected, takes its merited place as the highest of the institutional activities.

When a high type of research man goes into a commercial position, much of the value of his work is lost to the direct and free use of the public. If he is worth the increased salary to the commercial house, he is certainly worth it to the community, and should receive remuneration sufficient to make his position acceptable. Many cases have occurred where high-grade research men have resigned from station work, not because they were in any way dissatisfied with the opportunities offered them, but because they could not afford, from a monetary standpoint, to remain in their positions. Some of the more important changes are noted as follows:

At the Alabama station, Dr. G. L. Peltier, head of the plant pathology department, resigned to accept a similar position at the Nebraska station. At the Arizona station a plant pathology department was added and J. G. Brown, formerly assistant in biology, was placed in charge.

Director Martin Nelson, of the Arkansas station, was succeeded by Dr. Bradford Knapp. Director H. J. Webber, of the California station, resigned at the end of the fiscal year and was succeeded by Dr. C. M. Haring.

At the Colorado station, Dr. W. W. Robbins, head of the botany department, resigned to take a position with a beet-sugar company, and was succeeded by Dr. A. K. Peitersen, of the Vermont station. The plant pathologist, J. H. Leach, resigned, and was succeeded by C. D. Learn, of the Oklahoma station. F. J. Chase was appointed to have charge of the farm-management work. Dr. W. G. Sackett, bacteriologist, returned after a year's leave of absence.

Director Harry Hayward, of the Delaware station, was succeeded by C. A. McCue. The agronomist, A. E. Grantham, resigned and G. E. Schuster was appointed to the position. L. R. Detjen, from the North Carolina station, was appointed associate horticulturist.

The plant physiologist of the Florida station, B. F. Floyd, and the chemist, S. E. Collison, left to go into commercial lines, and were

succeeded by Dr. R. W. Ruprecht. T. E. Keitt, chemist of the Georgia station, resigned. T. S. Buie was appointed agronomist.

At the Idaho station, Dr. P. P. Peterson, soil technologist, resigned, and G. R. McDole, from the Minnesota station, succeeded him as associate agronomist. Dr. J. J. Putnam, of the bacteriology department, severed his connection with the station, and Dr. Paul Emerson, head of that department, resigned and was succeeded by Dr. W. M. Gibbs. H. P. Davis was appointed head of the dairy department and vice director of the station. S. P. Smyth was placed in charge of the poultry department, to succeed Pren Moore, resigned. Other resignations included the professor and associate professor of agricultural engineering, the associate animal husbandman, and the veterinarian.

At the Illinois station the staff was reduced 25 per cent below its normal number, the severest loss being the death of Dr. C. G. Hopkins, vice director and agronomist, who died on his way home from Greece, where he had been to assist in stimulating agricultural production during the war. Dr. W. L. Burlison was appointed to succeed him as agronomist.

C. G. Woodbury, director of the Indiana station, resigned, and was succeeded by G. I. Christie, previously director of extension, who combined the duties of the two offices. A number of other changes occurred that did not involve heads of departments.

The changes at the Iowa station were quite numerous, involving 21 appointments and 16 resignations, mainly among the assistants. At the Kansas station the head of the department of agricultural economics resigned and a number of assistants were appointed.

Changes at the Kentucky station included the appointment of Dr. W. D. Valleau, of the Minnesota station, as plant pathologist, E. L. Jackson as vegetable histologist, and R. H. Ridgell, of the Arkansas station, as fertilizer chemist, succeeding W. Rodes.

Director W. R. Dodson, of the Louisiana station, resigned at the end of the fiscal year, and was succeeded by Dr. W. H. Dalrymple. Dr. F. W. Zerban, sugar chemist, and Dr. N. Kopeloff, bacteriologist, resigned to go into commercial lines. A. F. Kidder, agronomist in the college, was appointed agronomist to the station, and assistant director A. P. Kerr was appointed chief chemist.

At the Maine station, Dr. F. M. Surface resigned as biologist and was succeeded by Karl Sax.

F. W. Morse continued as acting director of the Massachusetts station until the end of the fiscal year, when S. B. Haskell was appointed director. Dr. J. K. Shaw, pomologist, resigned to accept a position at the West Virginia university and station, but returned before the close of the year. W. W. Chenoweth was appointed head of the department of horticultural manufactures. F. A. Waugh, of

the horticultural department, Dr. G. E. Gage, animal pathologist, and J. C. Graham, poultryman, were reinstated from leave of absence for war service.

At the Minnesota station, Dr. L. S. Palmer, of the Missouri station, was appointed dairy chemist, and Dr. J. D. Black, chief of the division of agricultural economics, the latter succeeding Dr. W. W. Cumberland. C. P. Bull resigned as associate agronomist. Dr. C. W. Gay, chairman of the animal husbandry group, and H. W. Vaughan, head of the swine section, resigned. W. H. Alderman, from West Virginia, was appointed head of the horticultural department. There were 16 appointments and 12 resignations among the assistants.

At the Missouri station, Dr. E. F. Hopkins was appointed plant pathologist. A. C. Dahlberg resigned as associate in dairy husbandry, also R. R. Hudelson, associate in soils, and T. J. Talbert, associate in horticulture.

Changes at the Montana station included the resignation of A. Atkinson, agronomist, to become president of the State college, and the appointment of P. V. Cardon to succeed him. O. B. Whipple, of the horticultural department, resigned.

L. W. Chase, head of the agricultural engineering department of the Nebraska station, resigned and was succeeded by O. W. Sjogren. Dr. E. M. Wilcox, of the plant pathology department, was succeeded by Dr. G. L. Peltier from Alabama.

J. H. Gourley resigned from the horticultural department of the New Hampshire station to accept the position in the West Virginia university and station vacated by Dr. J. K. Shaw and was succeeded by G. F. Potter. Dr. H. R. Kraybill was appointed station chemist.

David Lumsden, of the department of floriculture at the New York Cornell station, resigned during the year.

Dr. J. O. Halverson was appointed to take charge of the animal nutrition investigations at the North Carolina station.

At the North Dakota station the chemist, J. W. Ince, resigned and was succeeded by L. T. Anderegg, who also resigned and was succeeded by T. H. Hopper. Other resignations included Dr. C. Yampolosky, plant pathologist, G. B. Rogers, dairy husbandman, and T. A. Hoverstad, in charge of market investigations, the latter being succeeded by W. R. Porter.

Dr. A. B. Cordley resigned the directorship of the Oregon station, remaining as dean of agriculture, and was succeeded by J. T. Jardine. W. S. Brown was appointed head of the horticultural department, succeeding Dr. C. I. Lewis. G. V. Copson was appointed head of the department of bacteriology.

At the Pennsylvania station, W. C. Pelton was appointed in vegetable gardening. Three associate professors resigned—E. L. Worthen,

of the agronomy department; G. S. Bulkley, of the dairy department; and W. H. Darst, of farm crops. The appointments included 36 assistants and instructors, and there were 15 resignations.

Dr. P. B. Hadley, in charge of the animal breeding and pathology work at the Rhode Island station, was succeeded by Dr. H. G. May. L. V. Starkey was appointed head of the animal husbandry department of the South Carolina station, succeeding R. L. Shields. Dr. C. A. Ludwig succeeded G. W. Wilson as associate in botany and plant pathology at that station, and W. J. Young was appointed associate horticulturist, to succeed L. H. Leonian, and later resigned. Dr. A. T. Evans was appointed associate agronomist at the South Dakota station.

At the Tennessee station, Dr. G. A. Metcalf, veterinarian, resigned at the end of the year, and the consulting meteorologist, J. F. Voorhees, resigned to leave the State. Three of the station staff—C. A. Willson, of the animal husbandry department; Maurice Mulvania, bacteriologist; and O. M. Watson, horticulturist—were transferred to the university, station work in these lines being discontinued. C. E. Allred was appointed head of the agricultural economics department.

At the Texas station, H. H. Laude, agronomist, resigned, and Dr. A. B. Cox succeeded H. M. Eliot as chief of the division of farm and ranch economics. F. B. Paddock, of the entomology department, resigned and was succeeded by Dr. M. C. Tanquary.

W. W. Henderson, of the entomology department of the Utah station, resigned to accept the presidency of the Brigham Young College, and Dr. B. L. Richards returned from work at the University of Wisconsin as associate plant pathologist.

At the West Virginia station, E. A. Livesay was appointed head of the animal husbandry department. Dr. J. K. Shaw, from Massachusetts, was appointed horticulturist (and later resigned), succeeding W. H. Alderman, who went to the Minnesota station. F. W. Stemple, the agronomist, resigned.

While many changes occurred in the Wisconsin station, they did not involve any heads of departments. At the Wyoming station, the associate chemist, K. T. Steik, resigned. Dr. J. W. Scott, parasitologist, was on leave of absence for the year, and Dr. J. I. Hardy resigned as wool specialist.

STATION PUBLICATIONS.

The increasing cost of paper and printing, coupled with straitened financial circumstances, has made it impossible for many of the stations to keep up in the publication of their work. Many manuscripts are held back because of inability to print them, and accounts of experiments which have been in progress for a considerable term of years are not prepared for publication for the same reason. The pub-

lishing item has become a heavy one with many stations. In notable instances it amounts to approximately $20,000, while in even the smaller institutions it amounts to $5,000 or more.

During the year the experiment stations issued 927 separate publications, embracing 22,275 pages. This represents a quite steady decrease for several years past. For instance, the number of publications was about one-third less than in 1914, and the total number of pages was little more than 10 years previous.

Furthermore, lack of funds has tended to decrease the size of the editions and has necessitated revision of the mailing lists, with special attention to limiting the number sent outside the States. In 1920 the mailing lists aggregated 933,933 names, while for many years it was considerably over a million. In a few cases, as an economy measure, announcements have been made of forthcoming publications and the distribution in large measure restricted to those who applied for them. There is still, however, a very wide circulation of bulletins outside the States in which they are issued, indicating in a striking way the fact that the work of these institutions is not merely of local interest and use.

To increasing extent the stations have published technical accounts of their work in various scientific journals of the country. Their manuscripts have been readily accepted, and publication in these journals serves to bring them to the attention of specialists most interested in them. A point has been reached, however, where such publication is less feasible than formerly, as most of these private journals are adjusting themselves to higher costs, and consequently have large accumulations of manuscripts, which delay issue. Several of the stations continue to publish technical series of bulletins devoted to investigations which have not reached a stage at which they are of general interest.

In a number of States larger attention is being given to keeping the public informed regarding the work and services the stations are doing. Many of the colleges now have editorial or publicity departments which the stations are able to take advantage of. Such publicity is very desirable and might well be made a more general feature.

NEW BUILDINGS AND EQUIPMENT.

Comparatively few larger buildings were added to the equipment of the stations during the year, due mainly to the high cost of materials and the limitations on the income of the stations. Equipment, apparatus, and live stock was, as a rule, maintained without any very large additions. The following items on equipment are noted:

The Arizona station added a foreman's house and machinery shed at the Salt River Valley farm and a barn at the Prescott dry farm.

Additional land was acquired at Yuma for an extension of the date orchard. An appropriation of $4,000 for a new dairy barn and $500 for a hog house, at the station at Tucson, became available.

The Arkansas university and station secured a farm of 423 acres, located 1¾ miles north of the campus, of which 60 acres are to be devoted to horticulture, 120 to agronomy, 10 to plant pathology and entomology, and the balance to pasture and general farming.

At the Colorado college and station a new physics building costing $93,000, a veterinary building costing $35,000, and a horse barn costing $3,500, were nearly completed. While the buildings are mainly for college use, they will be of considerable help to the station in extending its facilities.

Three small silos were built at the Connecticut Storrs station, fences costing about $650 were constructed, and a flock of 33 sheep was added to the live stock.

At the Idaho station a poultry building, costing about $1,500, was added and two students' Army Training Corps buildings were transformed into a storage building for horticultural and farm crops at a cost of $600. A feeding barn and silo, costing $4,500, were erected at the Caldwell substation, and a sheep barn and machinery shed at Sandpoint, at an expense of $600.

The Indiana station secured a 5-years' lease of a farm, which will be devoted to swine experiments. A model country house, new barn, and tool shed were erected on the Wilson farm, and a barn and poultry house are being built on the Bedford farm. At the university a horse barn, costing $30,000, and a cattle barn, costing somewhat more, with concrete silos, were completed.

The Iowa station has $75,000 available for the purchase of a farm, near the college campus, which will be used by the animal husbandry department. Numerous minor improvements were carried out at the Kentucky station, including repainting of all of the barns, fencing, road building, and the installation of new equipment in the dairy barn. An abattoir with a refrigerating plant was completed and considerable live stock added. The Louisiana station also reports considerable repair work and additional apparatus in many of the departments.

The Maine station lost by fire all of the records of a series of years' work on genetics. At the Aroostook farm the roof of the barn fell in, from snow load, costing about $1,700 to replace, and the tool shed at Highmoor was burned, with a loss of $1,838. A new cattle barn is being erected at the Highmoor farm.

The Michigan station secured a farm of 40 acres at Chatham for $4,000, and a small laboratory was constructed for work with small animals. Additional facilities for both the station and college have

been provided in horticulture, forestry, and plant physiology and pathology, by the remodeling of the horticultural and agricultural botany building, at a cost of $90,000. The Missouri station has rented a farm of 330 acres for animal husbandry work.

At the Nebraska station the animal pathology laboratory was finished at a cost of $60,000, thus completing the entire plant, which has cost about $125,000. Tractor-testing equipment was installed, valued at $35,000. On the agronomy farm a hay shed costing $2,500 and a machine shed costing $1,000 were erected. At the Union fruit farm, a residence costing $4,500 and a barn costing $1,800 were completed. New buildings at the North Platte substation included a horse barn costing $20,000, a residence costing $4,200, and buildings and equipment for the poultry plant costing $7,000.

A new horticultural building was under construction at the New Jersey station, and additions were made to the soil house. The New Mexico station built a four-room adobe residence for the poultry department.

The agricultural college at Cornell University is to add four new buildings, from an appropriation that will eventually amount to about $6,000,000. Part of these will be devoted to research and will directly benefit the station.

At the Ohio station, a new block of greenhouses, costing about $9,820, was completed and occupied. A new dairy barn has been provided for at the Oklahoma station, which will probably be completed during the coming year. A house was erected on the agronomy experiment station farm, for the foreman. Six experimental silos and considerable equipment and apparatus were added to the Oregon station.

At the Porto Rico station, two warehouses from the military camp at Las Casas were converted into three residences for members of the station staff.

A calf and a hog barn were erected at the South Carolina station, costing about $6,000 each, and an office building and corn barn were added to the Pee Dee substation. At the Tennessee station, two large barns were completed on the Cherokee farm. The buildings under construction at the middle Tennessee station include an administration building, stock barn, horse and implement barn, dairy barn, and four cottages for laborers.

A new water tower was constructed at the Texas feeding and breeding station, with a capacity of 30,000 gallons, at a cost of $5,000.

During the year, the buildings provided by the last Legislature of Utah were completed and occupied. The irrigation and drainage department is now housed in the new agricultural engineering building, and the plant pathology and agronomy departments in

the plant industry building. A seed house for the agronomy department and a new horse barn have been completed and occupied.

At the Virginia station, a laborer's cottage costing $2,300 was built. The station has purchased a tract of 36 acres at Bowling Green and erected a cottage and barn at the substation there at a total cost of $5,700. Experiments in sun-cured tobacco will be carried on.

Work was begun on a new dairy building at the Washington station, to cost $100,000. The legislature appropriated $35,000 for an experiment station for irrigation farming at Prosser, on a tract of 205 acres, and the erection of buildings was begun.

At the West Virginia station, barns were completed on the agronomy farms and needed equipment added to all departments.

A student army barracks at the Wisconsin station was remodeled for an experimental hog-feeding barn. At the Wyoming station two rooms were added to the foreman's house on the agronomy farm, and the horse corral was rebuilt. At the stock farm a double house was built for the men, and a steer-feeding shed and hollow-tile silo erected.

NEW LEGISLATION.

In most States the legislature did not meet during the year or no legislation affecting the station was enacted. Those States where such action was taken are as follows:

In Alabama, the first State appropriation for the central station for work at Auburn was made, to take effect October 1, 1919, carrying $5,000 for the first year and $7,500 each for the next three years. An appropriation was also secured for animal husbandry work of $10,000 a year for two years and $12,500 a year for the two following years, which, while entirely independent of the station, may be used for college equipment, and may thus aid in experimental work.

The Arizona Legislature appropriated $10,000 for the purchase of land on the Yuma mesa to increase the experimental work being done in citrus investigation, and chapter 153, Session Laws, 1919, placed upon the irrigation department the task of carrying out extensive water-supply investigations in Cochise County. At the California station three new lines of work were provided for by special appropriation, including $5,000 for deciduous-fruit investigations, for which a branch station has been established at Mountain View; $4,000 for range experiments in beef production, to be carried out on 4,000 acres of leased land at Shingles, Eldorado County, with the use of 27,000 acres of forest reserve; and alkali investigations at Fresno. The Georgia Legislature appropriated $25,000 for a coastal plains station at Tifton, the local community giving also $25,000 and land. A law was also passed requiring all printing of State institutions, including

the station, to be done on requisition filed with the State superintendent of printing, this applying to letterheads and forms as well as bulletins.

The Louisiana Legislature authorized the State Board of Agriculture and Immigration "to establish at some suitable and accessible point in the strawberry and truck-growing belt of the Louisiana Parishes a branch of the State experiment station, for the purpose of carrying on scientific and practical investigations pertaining to the most economical production of the strawberry, other fruit and truck crops in general, preservation of soil fertility, irrigation, and drainage, the ravages of insect pests and fungus diseases and means of combating them, the study of the varieties of strawberries, fruits, and truck crops, the grading, marketing, and other problems that are or may become vital to the development and maintenance of the fruit and truck industry of Louisiana."

In Maryland, while there was no direct State law affecting experiment station work, the General State Budget Law, Central Purchasing Agent Law, and Merritt System Law, all affect the station, making the available funds less flexible and imposing many regulations which retard progress, entailing much detailed clerical work, which adds to the expense of transacting the station business. The Massachusetts station also suffers from the supervision of all of its financial affairs by the State superintendent of administration, the system imposing many hardships on the station in the free use of its funds, both Federal and others. Estimates and appointments must be made dating from December 1 to June 1, and then to December 1, and it is practically impossible to secure changes in any salary or the appointment of new men between these dates, even to meet emergencies. The purchase of material and authority for travel, especially outside of the State, involve much delay. The regulations are proving a considerable handicap and are clearly unsuited to the needs of a research institution in which circumstances may require the taking up of lines which may arise from an emergency or materials which can not be prophesied in advance. The requirements and their effects are such as to raise a question whether the State is not exceeding its authority in thus restricting the use of the Federal funds.

The Minnesota Legislature no longer makes an appropriation direct to the station or for special agricultural investigation, but the financial needs of the station are included in the general budget of the university as a part of that of the college of agriculture.

In Mississippi the last session of the legislature authorized the establishment of a new branch station, locating the same at Raymond, in Hinds County. The appropriations include $6,000 for the purchase of land, $6,000 for buildings, and $5,000 for each of the years 1920 and 1921 for support.

As a result of an initiative vote, the University of Montana will receive from a bond issue $3,750,000 for building purposes, of which $1,500,000 will accrue to the college of agriculture. In addition, an amendment to the State constitution was voted whereby the various institutions grouped under the University of Montana will receive a 1.8-mill maintenance tax.

The 1920 session of the New Jersey Legislature amended the Glassware and Testers' License Law, giving additional powers and finances to the station, making it possible to adequately enforce the law. An enabling act, known as Chapter 126, was passed, giving the power to carry out investigations on the biology of sewage disposal. An act was also passed authorizing the experiment station to superintend poultry shows, to stage educational exhibits, and to offer premiums at said shows, carrying with it an appropriation of $10,000, $4,000 of which was made available for the current year's work. The old Vineland Contest Act was repealed and a substitute act passed authorizing the supervision of three such egg-laying contests and breed-testing stations and an appropriation of $13,000 for the work, of which $10,000 was made available for the current year.

The Oklahoma station received $10,000 for maintenance, as a direct appropriation from the legislature for the first time, it being previously set apart by the college for the station. In May, 1920, the people of Oregon approved a millage tax measure providing additional funds for the resident instruction work of the college. While no part of the funds from this tax or from the original millage tax of 1913 is devoted to station work, more adequate provision for resident instruction is of incidental advantage to the station work. The withdrawal of the Federal appropriations for irrigation agricultural investigations at the Umatilla station, for cereal investigations at the Burns station, and for forage-crop investigations at the Moro station made it difficult to conduct the work at these stations effectively.

The Legislature of South Carolina appropriated $25,000 a year each for the central and branch stations, to relieve the college and supplement station funds. This is an important innovation, as heretofore the station has received no funds directly from the State, but its local support has come from the college tag-tax fund.

The Virginia Truck Experiment Station was made a permanent State institution by the General Assembly, to be under the control of a board of directors consisting of five members, two of whom shall be the chairman of the board of control of the Virginia Agricultural Experiment Station at Blacksburg and the president of the Virginia Polytechnic Institute. The law also provides that the same board of directors shall have the management and control of the

Eastern Shore Experiment Station, located near Onley, Accomac County.

In Wyoming nine farms formerly in charge of a State farm board were placed in charge of the station, with appropriations amounting to $25,000 for their support.

SUBSTATIONS.

The establishment of substations or branch stations supported by State or local funds has been adopted in many States. A number of the stations carry on extensive cooperative field experiments with representative farmers or on leased lands over the State, endeavoring as a rule to cover the more important soil types. In many States both systems have been adopted.

The plan of extending the experimental work to typical sections of the State has been found advantageous, and in some cases quite essential to a study of local problems. In addition to the broad testing of results secured at the central station, such work brings out the local adaptation which may be necessary.

The establishment of branch stations on land owned by, and therefore under permanent control of, the station is the more satisfactory arrangement of the two systems, as the investigations are assured of unbroken continuance, the laying out and oversight of the work can be carried on to much better advantage, and any improvements, buildings, drainage, fencing, etc., remain as permanent additions.

In default of this a good system of experiment fields over the State affords much needed opportunity for more extensive trials under differing conditions than would be possible at the central station. In practically all States there is a wide divergence of conditions as to soil, altitude, rainfall, and climate, and oftentimes in the particular lines of agriculture practiced, and without provisions of some kind for work over the State it is difficult for a station to reduce its results to a point where they may be safely turned over to the extension service.

In many States the branch stations have received liberal support and have been developed on quite an extensive scale, with permanent plats and plantations, and provision for feeding trials on an extensive scale. As a rule they are not provided with laboratory facilities, being devoted to agronomical, horticultural, or live-stock experiments in the field. They therefore have their limitations, but where they are under the immediate supervision of the director and staff of the central station the work can be maintained on a satisfactory grade and coordinated with that of the main station.

The following is a list of such outside activities of the stations, omitting the more general cooperative work with farmers which is

carried on to a greater or less extent by nearly all the stations. Many of these outside activities are conducted in cooperation with the U. S. Department of Agriculture.

In Alabama cooperative experiments are conducted under the State local experiment funds, with over 200 cooperators in the State. The station has no branch stations.

The Arizona station conducts two dry-farm substations, located at Cochise in the Sulphur Springs Valley and at Prescott; two experiment farms, one at Mesa in the Salt River Valley, and the other at Yuma; and a date-palm orchard at Tempe, with a small orchard at the Yuma substation.

The California branch stations include the farm located at Davis, devoted to general agriculture and horticulture, the citrus experiment station at Riverside, the station in the Imperial Valley near El Centro, where field and horticultural problems are studied, the Kearney farm at Fresno, for field and horticultural experiments, the deciduous-fruit station at Mountain View, and two forestry stations at Santa Monica and Chico. In addition, range experiments are carried on at Shingles and Placerville, and alkali and other problems are studied at Fresno.

The outside activities of the Colorado station include the Plains station at Cheyenne Wells, devoted to dry-land work with field crops, fruit, and dairying; the high-altitude station at Fort Lewis, at an altitude of 7,000 to 9,000 feet, devoted to crop adaptation; the Arkansas Valley station at Rocky Ford, for experiments with alfalfa and corn especially; and the Akron dry-land station, where experiments are being made with summer fallow and sheep pasturage.

In Florida a branch station has been established at Lake Alfred for the citrus industry; a substation has been provided for at Quincy for tobacco experiments, and land and funds set aside for a station in the Everglades.

The Georgia station conducts no branch stations, but the State supports an independent institution, under an entirely distinct governing board, at Tifton, under the name of the Coastal Plains station.

The substations in Idaho include Caldwell, devoted to diversified farming and live stock; Aberdeen, used for irrigation experiments; the high altitude station at Felt; the cut-over-lands station at Sandpoint for work with cattle, hogs, and land clearing; and a horticultural substation at Jerome.

The agronomy department of the Illinois station conducts 27 cooperative experimental fields over the State for work on soil fertility, and the horticultural department maintains field and orchard experiments at Olney and Anna.

The Indiana station conducts a farm at Bedford (the Moses Fell Annex) for crops, fertilizers, spraying, alfalfa, and soil management; the Pinney-Purdue farm at Wanatah, for soil-fertility studies on unproductive sandy soil; and a forestry station at Farmland.

The outside activities of the Iowa station include a fruit-breeding farm at Charles City, an orchard at Council Bluffs, and some 80 cooperative experimental fields on important soil types.

The Kansas station operates substations at Garden City for irrigation and dry-land agriculture, at Fort Hays for work with crops and live stock under semiarid conditions, at Colby for irrigation studies, and at Tribune for dry farming.

The Kentucky station has no branch stations, but operates a number of experimental fields over the State, some owned by the station and some conducted cooperatively.

The branch stations in Louisiana include the Sugar station at Audubon Park, New Orleans; the station at Calhoun, devoted to both field and live-stock work; and the rice experiment station at Crowley. The station also cooperates with the U. S. Department of Agriculture at the New Iberia live-stock experiment farm, and will probably establish a fruit and truck station in Tangipahoa Parish.

The Maine station has two branch stations, the Aroostook farm at Presque Isle for potato studies and the Highmoor Farm at Monmouth for fruits, field-crop, and pasture studies.

The Maryland station has one branch station, at Ridgeley.

Two branch stations are conducted in Massachusetts, the market-garden field station at Lexington and the cranberry substation at Wareham.

The Michigan station conducts the Upper Peninsular substation at Chatham, devoted to land clearing, crop production, live-stock breeding, grading, and feeding; the South Haven station, devoted to horticulture; and the Graham farm, near Grand Rapids, for investigations in horticulture, cover crops, and breeding small fruits.

The substations in Minnesota include the north central experiment farm at Grand Rapids, the northeast demonstration farm at Duluth, the northwest experiment farm at Crookston, the west central experiment farm at Morris, the southeast demonstration farm at Waseca, the fruit experiment farm at Zumbra Heights, and the Cloquet forest experiment station.

The Mississippi station conducts branch stations at Poplarville for field and truck crops and horticulture; at Holly Springs for field, horticulture, and dairy studies; the delta station at Stonerville; the Raymond branch station; and continues some cooperative work at the McNeill station, although this has been largely transferred to the Bureau of Animal Industry of the U. S. Department of Agriculture.

The Missouri station has no branch stations under its control, but conducts a number of soil experiment fields over the State. Separate stations for fruit growing and poultry raising are maintained by the State at Mountain Grove.

The Montana station conducts five substations, including the horticultural substation located at Victor near Corvallis, in the Bitter Root Valley; the North Montana station at Fort Assinniboine, near Havre; and the Judith Basin dry-farm station at Moccasin. It also conducts the Fort Ellis farm near Bozeman, devoted to dry-land farming and live-stock experiments, and cooperates with the U. S. Department of Agriculture in experiments at the Huntley substation on a reclamation project near Billings.

There are substations in Nebraska, at Scotts Bluff, for soil fertility, forage crops, and irrigation farming; at Valentine, for forage crops and dairying; and at North Platte, for work in animal husbandry, agronomy, and dairying. A fruit farm is conducted at Union, about 40 miles from the central station (Lincoln).

Nevada and New Hampshire have no substations. The New Jersey station has no branch stations, but conducts the Vineland international egg-laying and breeding station, and also cranberry work at Whitesbog in Burlington County.

The New Mexico station cooperates with the U. S. Department of Agriculture in experiments on the dry land field station at Tucumcari, devoted to rotations, tillage methods, hog pasture, and variety tests.

In North Carolina the substations include the coastal plains station, on the Pender farm at Willard, the Piedmont station at Statesville, the Blackland farm at Wenona, the Black Mountain farm, a tobacco station at Oxford, and a test farm at Rocky Mount.

In North Dakota substations are maintained at Langdon, devoted to fruit, cereals, and crop rotations; at Hettinger for dry-land farming and live stock; at Edgeley for fruit, rotations, pastures, and pork production; at Dickinson for dry-land farming, and at Williston for live stock.

The branch stations in Ohio include the northeast test farm at Strongsville; the northwest test farm at Findlay; the southeast test farm at Carpenter; the southwest test farm at Germantown, and the Washington County truck farm at Marietta. In addition to these the station conducts a number of county experiment farms, some owned and some on leased land.

The outside activities of the Oregon station include the eastern Oregon branch substation at Union, the dry-land substation at Moro, the John Jacob Astor station at Astoria, the Umatilla substation, the southern Oregon substation at Talent, and the Harney Valley substation at Burns. In addition to these, there is an irrigation

demonstration farm at Redmond, a dry-farm demonstration farm at Metolius, and a substation at Hood River for fruit studies.

Two substations are operated by the South Carolina station, one at Florence, called the Pee Dee station, and one at Summerville, known as the coast station. In addition, a system of cooperative experiments in various sections of the State has been inaugurated.

The South Dakota station conducts substations at Eureka, Highmore, and Cottonwood, and a demonstration farm at Vivian.

Tennessee has two substations, the west Tennessee station, located at Jackson, and the middle Tennessee station at Columbia. In addition, the station conducts a tobacco experiment station at Clarksville, and carries cooperative experiments in four other localities in the State.

The Texas station owns and operates 13 substations, as follows: Beeville, devoted to irrigation, orchard, truck, and field crops; Troup, for diversified truck, fruit, and field crops; Angleton, for testing varieties of general field crops; Beaumont, working especially with rice; Temple, for investigations in cotton and cotton diseases as well as other field crops; Denton, mainly for small grains, legumes, and other field crops; Spur, for sheep and lamb feeding, and breeding experiments with field crop work; Lubbock, devoted to dry farming, windmill irrigation, and field crops; Pecos, which includes both field crop and orchard experiments; the feeding and breeding station near College Station, for live-stock feeding and breeding work; the tobacco experiment station at Nacogdoches; Chillicothe, for forage crops, small grains, and cotton; and the Sonora station, for breeding and improvement work with sheep and goats.

The Utah station maintains nine experimental farms, which include the Davis County farm at Farmington, especially for canning crops; the Panguitch farm for live stock; the Greenville farm for irrigation; the dry farm at Cedar City; the southern Utah experiment station near St. George, for horticulture; the Kanab and Widtsoe experimental farms; the central Utah station at Lehi; and the dry-farming station at Nephi.

The Virginia station supervises county experiment stations at Appomattox, Bowling Green, Holland, Chatham, and Lightfoot, and also three substations for the State Board of Agriculture, located at Staunton, Martinsville, and Charlotte Court House.

The Washington station conducts three branch stations, one at Lind, in Adams County, for dry farming; the Waterville branch, for forage problems; and an irrigation station at Prosser. The Puyallup station in the western part of the State is not under the control of the director of the central station.

In West Virginia the station owns the Reymann Memorial farm at Wardenville, and is conducting cooperative experiments with the

U. S. Department of Agriculture on cattle at Lewisburg and on tobacco at Guyandotte.

Wisconsin has three substations, one at Spooner, devoted to potato work and dairying; one at Ashland Junction for dairy, wheat, pea, and clover experiments; and one at Marshfield for drainage studies. Two experimental fields have recently been added, one at Hancock on poor sandy soil and one at Coddington on marsh soil, both for studies as to how these soils may be profitably farmed.

In Wyoming provision has recently been made for nine substations, including those at Lander, Sheridan, and Gillette, already established, the latter in cooperation with the U. S. Department of Agriculture. Others are located in the towns of Lyman, Grover, Eden, Archer, Torrington, and Jireh.

PROJECTS OF THE EXPERIMENT STATIONS.

A classified list of projects conducted by the experiment stations was compiled for the first time in 1919, as mentioned in the preceding report. The interest which this list developed as a means of keeping abreast of the work of the stations and enabling station workers, as well as those in the department, to know where certain types of investigations are being carried on, led to a revision of the list to cover the projects in operation in 1920. This list, like its predecessor, was issued in mimeographed form. It is more complete than the preceding one, enumerating over 4,200 separate projects. These cover every conceivable topic in the range of agricultural inquiry. In the classification scheme the entries are duplicated to considerable extent in order to index them more fully, and many cross-references are given.

Grouped by subjects, the list shows 1,468 projects in agronomy, 639 in horticulture, 587 in animal husbandry, 344 in diseases of plants, 340 in entomology, 109 in dairying, 164 in veterinary medicine, and 322 miscellaneous.

The largest number of entries is under the head of field crops, comprising one-fourth of the total. Corn leads the list of crops with 147 projects. Irish potatoes has 96, wheat 80, oats 69, rotations 60, and alfalfa and cotton each 57. Horticultural projects come second, with a total of 743, under which the leading headings are: Apples, 100 entries; fruits, general, 60; vegetables and truck crops, general, 49; grapes 39, peaches 32, and orchard management 31. The next largest heading is diseases of plants, with 409 entries, the crops having the largest number being potato diseases 51, tomato diseases 30, and apple diseases 29. This is followed by economic entomology with 356 projects, the leading subjects being, bees 35 entries, apple insects and insecticides 20 each, and the codling moth and corn

insects 13 each. The next largest general subject is soils, with 259 projects, under which the leading subheads are soil fertility 52 projects, soil types 29, soil flora 28, and soil surveys 18.

The animal husbandry group is led by poultry with 191 projects, followed by swine with 147, beef cattle 78, sheep 63, and horses 13. Dairy farming includes 128 projects and dairy products 80. There are 181 entries under veterinary medicine, poultry diseases leading with 40 entries.

Other main headings in the order of number of projects are fertilizers 414, rural engineering and rural economics 128 each, feeding stuffs and animal nutrition 122, genetics 97, botany 90, chemistry 69, and foods and human nutrition 57. The smallest number of entries is under meteorology with 7 projects.

The list brings out little, if any, actual duplication of work which is not necessary to meet the needs of localities or well-rounded studies of large problems. While there is a certain similarity among projects carried by different States, familiarity with the projects shows that they have specific differences and are mainly on an individual basis. While various stations are studying the same general subjects, the nature and purpose of their inquiries or experiments vary in different instances, and unnecessary or undesirable duplication is reduced to a minimum.

The average number of projects per station is 81, with 70 under the Hatch and other funds, and 11 under the Adams fund. The range represented by this average is, however, quite a wide one.

There is already evidence that the compilation of such a list of projects is bringing about a better understanding among the stations in regard to their activities, and that their work is being more specifically outlined. It has tended to remove unnecessary duplication and has gone a long way in the direction of promoting successful cooperation.

NEW LINES OF INVESTIGATION NEEDED.

A request to the stations for suggestions as to the lines of work which should and could be carried on if sufficient funds were available has brought out some interesting and significant points. The replies received emphasize the fact that not only are the stations running with a very reduced efficiency on account of the lack of sufficient research men, for whom salaries can not be provided, but that there are numerous pressing problems that demand investigation and on which the stations are called upon for expert advice that can only be secured through investigation.

Many of the stations have more or less equipment and facilities for departments that have had to be temporarily abandoned because

of inability to pay the salaries of men to carry them on. This means an enforced lack of efficiency and inability to secure results that are urgently demanded.

The replies received from almost every station brought out not only the serious disadvantages under which it was working, but indicated a number of very pressing problems of practical application which promise large returns on the amount needed to investigate them. Extracts from a few only of the replies received are given here, which will illustrate the general conditions. A complete list of the projects submitted that require more or less immediate attention would cover many pages.

Among a long list of subjects urgently needing investigation by the Alabama station are a number that would seem to be of great importance to the South, including soil-fertility studies involving the residual soil-improving or soil-exhausting effects of the principal southern crops; the carrying capacity and best means of utilizing by harvesting by animals of many crops not heretofore thus investigated; a systematic study of southern crops suitable for the silo, with lime requirements of the principal soil types and of all the southern field, forage, and fruit crops; numerous plant diseases require further investigation, including those of pecans, cowpeas, and soy beans; a number of serious insect pests should receive attention, including the bud worm, the woolly aphis, and the Mexican bean weevil; also a study of the oils and their treatment, from soy beans, chufas, and other crops, with a view to ascertaining their fitness for various industrial purposes.

In Arizona, investigational work is needed along the lines of suitable feeds for pork production in that State, as well as proper care and management of swine under the conditions peculiar to that section; furthermore, there is need of investigations on the production of live stock under range conditions, including breeding, feeding, and management.

Some of the important Arkansas problems are the place of the tractor on Arkansas farms; sheep production, especially for the rough lands of the State; the relation of frost injury to methods of cultivation and fertilization of fruit; pasture mixtures for the cotton section; farm management and marketing studies; rice insects and diseases, and the rotation of crops for rice farms; the best type of farming for cut-over lands; and the cheapest method of putting raw land into good condition for crop production.

Many of the problems presented by the California station are of wide application throughout the West. One of the most important problems of California agriculture is the successful control of the spread of alkali. The sugar-beet industry, representing a capital of $25,000,000, is threatened with total destruction if means are not

found to control curly top and render production more secure. The proper handling of large tracts of land that can only be used for dry farming is a very important problem, and the most effective methods of treating the same and the crops best adapted for them require systematic experimentation; a thorough understanding of tillage and moisture conservation is of great importance; nematode root knot has become widespread in various parts of the State and is doing serious damage to many crops, and presents a serious and difficult problem that should receive thorough investigation; the injury caused by wireworms is a problem that vitally concerns every agricultural section of the State; range investigations need attention as well as beef-production problems.

The investigations of the Connecticut State station on proteins and vitamins are of fundamental importance, and could be greatly advanced if sufficient funds were available.

In Delaware investigations are needed along the lines of insects injurious to fruits, the storage of fruits, and development of uses for by-products of the fruit industry, and problems in milk and pork production.

The Florida station has been obliged to discontinue the plant-physiology investigations and now has only four heads of departments on its staff. Many of the problems of the State are somewhat unique. The live-stock industry is a growing one, and a great many problems are waiting to be solved.

The pecan industry of Georgia is rapidly growing and the results already secured by the station have caused growers to look for further relief; the inroads of the curculio and brown rot of peaches have virtually demoralized the industry in the State; with the cotton boll weevil sweeping the State a new order of agriculture is necessary; and more funds are urgently needed for investigation of the feeding value of velvet beans, soy beans, cottonseed meal, and especially peanuts. The growing importance of hog raising demands more extended knowledge of the utilization of these products in an economical manner with the least harmful effects on the quality of the meat.

The Idaho station reports that additional investigation should be undertaken in dairy-cattle feeding, home economics, and rural sociology.

At the Illinois station funds are lacking to carry out the studies necessary to answer the many questions that arise in regard to market credit and finance. There is an inadequate staff for the study of plant and animal diseases, and the field of normal plant and animal physiology is practically untouched. Questions arise in animal feeding which can not at present be investigated; many new problems in connection with the operation of farm machinery, which is becom-

ing a constantly increasing factor in agriculture, are being submitted for investigation.

A few of the lines of work which the Indiana station desires to take up include breeding investigations with cattle and horses; a more thorough study of the diseases of horses, cattle, and sheep; a study of septic tanks; fruit-bud development; drainage investigations; soil toxicity, giving special attention to available boron and aluminum; special problems involving plant breeding and plant physiology studies; and a through study of several of the fruit diseases.

Among the numerous problems submitted by the Kansas station is expansion of the work in agricultural economics, especially in cost of production and marketing; an extensive study of the winter hardiness of wheat in the hardy winter-wheat belt; continuation of the soil survey and establishment of experiments on different soil types of the State to supplement the work of the main station; studies regarding the best methods of utilizing sorghum grain as a feed for live stock; experiments in horse feeding under present conditions; fattening cattle on grass; extension in investigations on animal diseases; control of injurious mammals; and native pest studies.

Some of the problems confronting the Kentucky station that can not be adequately investigated on account of lack of funds are cause and control of bloody murrain in cattle; development of resistant types of tobacco, and the physiology and changes involved in curing and methods of controlling same; cost of crop and meat production; method of production of hay and pasture grasses in the mountain area; orchard investigations in different parts of Kentucky; and the relation of the various soil types of the State to the application of fertilizers.

The greater need of the biological investigations of the Maine station is for maintenance of projects that are already in progress. The poultry investigations have had to be run at their lowest ebb, and the animal husbandry studies are in a very precarious state. On account of loss of members of the staff, it is doubtful if the work on cereal breeding can be continued. More productive forage and root crops are desired by the dairy farmers of the State. The important work along entomological lines which this station has done will depend upon adequate funds for their continuance.

The Maryland station has many problems in connection with the live-stock industry, particularly forage crops for hogs, and dairy problems, which can not be undertaken for lack of men and funds. The work with crops, particularly soy beans, cowpeas, vetches, and other leguminous crops as soil improvers and for forage, should be much extended. There is need for much work with pasture grass suited to different soil types in different parts of the State, and work with market-garden and fruit crops could be profitably extended.

The particular lines of work which await necessary funds at the Massachusetts station are investigations of apple diseases in the eastern part of the State; more extensive experimental work in market gardening, in soil management and plant nutrition as related to fruit trees; canning investigations; and more extensive studies in rural sociology.

The Mississippi station reports the necessity of additional funds for studies in agriculture and home economics. A complete soil survey and determination of the fertilizer requirements for the different soil types has never been made, and it is desired to carry on cooperative fertilizer experiments in each county for the different farm and garden crops to determine the fertilizer requirements.

The Montana station emphasizes the need of extension of the work in agricultural engineering, especially in drainage and irrigation problems, and also reports that agricultural economics and marketing studies should be undertaken. Considerable expansion of all of the departments is very much desired.

The needs of the Nebraska station include investigations of systems of marketing farm products and a thorough economic study of the entire marketing system from the farmer to the consumer, looking to a more direct and less curtailed system. Fundamental research in chemistry as it relates to soil fertility, animal nutrition, and plant growth should be largely increased. It is desired to make investigations on the part played by ash, protein, and the vitamins in economic pork production, and similar studies should be undertaken in the feeding of young chicks to secure healthy and rapid growth, together with economic production; investigations of the diseases of the honeybee and of honey-producing plants to increase production in the State is very important; more extended studies of the relation of barberry to the spread of wheat rust should be made, investigation of potato diseases should be greatly extended; surveys are needed to determine the extent of acid soils in the State, as an aid to increased production; also investigations to determine the most efficient methods of handling range pastures in order to extend and protect their grazing qualities.

In Nevada, stockmen are showing great appreciation of the value of feeding experiments and studies of poisonous plants, and are demanding further information which can be gained only by a long series of experiments, facilities for which are lacking. The station has found it necessary not only to reduce its working force, but also to concentrate in a few lines the work it is able to do for the important live-stock industry of the State.

Among the needed investigations at the New Jersey station are a chemical study of the potash requirements of the soils of the State; studies on market milk production and dairy cattle nutrition; farm

management studies, including farm power in relation to farm efficiency; cost of marketing and cost of production of various crops; the improvement of farm crops by breeding and selection; further studies in all lines of plant diseases, including truck, fruit, and field crops; studies on the oriental peach moth, and dusting investigations. Investigations are also needed in connection with peach yellows "and little peach," as well as many floricultural problems.

The New Mexico station reports the necessity of further investigations on the improvement and management of New Mexico poultry; studies on the improvement and management of range cattle and sheep; investigations, surveys, and eradication of New Mexico poisonous plants and shrubs; a study of *Atriplex canescens* in respect to its range of adaptability as regards altitude, soil moisture, soil, rainfall, and temperature, as well as the development of methods of eradicating it in a practical way; also studies on the keeping qualities of different varieties of fruits and vegetables under arid climatic conditions.

Some of the projects that await the necessary funds for development at the New York Cornell station are, the rearing of calves on milk substitutes and the protein requirements for milk production; the effect of maturity on the value of corn for silage when used in milk production and a thorough study of means of increasing the value of pastures should be undertaken. The station is also desirous of making a study of the extent of variability in lime and fertilizer requirements in each soil type found in the State.

The Oklahoma station reports much need of investigation in agricultural economics, practically no work having been done in this line in the State. Studies of crow control are of great importance, as the crow is protected in Kansas and Nebraska, and it is estimated that the cost of supporting it in Oklahoma runs into millions of dollars per year; potato investigations are badly needed; also studies of melon diseases; feeding investigations should be very much enlarged, there being a great demand for knowledge along this line. Practically nothing is known concerning the soils of the State, and greenhouse investigations should be carried on with proper chemical analyses to provide definite information as to their fertilizer requirements; crop rotation systems should be investigated, especially in the cotton-growing section; drainage and erosion studies demand attention; a great many problems should be taken up, including plant assimilation, the movement of plant food in soils, plant physiology, and soil acidity; the problem of the tight clay or hardpan, which occurs over most of the State, is no nearer solution than it was 40 years ago. Lack of funds has brought the station work nearly to a standstill.

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The Oregon station reports that no other lines of station work are more widely in demand than those relating to farm crops, including crop improvement, tillage methods, and crop rotations for Oregon conditions, weed control, and the establishment and maintenance of pastures. Facilities should be increased if the station is to meet the complex and important soil problems of the State. In dairying there are many problems of production and marketing upon which further information is needed, as well as investigations relative to feeds and feeding. There are urgent requests for investigations on the control of insect pests of the yellow pine; the pear thrip is proving very destructive and should receive attention, also the control of the alfalfa weevil. The station has no staff member and no provision for cost of production studies. Important investigations in the problems of feeds, feeding houses, and general management of poultry must be deferred until additional funds are available.

At the Pennsylvania station, among the various lines of investigation that should be taken up are studies relative to methods of maintaining and improving pasture lands of the State; the cause of abandoned farms and unproductive soils in the vicinity of manufacturing plants; the cost of production of farm crops; animals and animal products; culture, feeding, and development; several important plant diseases; protein requirements for the growth of dairy calves; feeding of home-grown rations to dairy cows; studies of ice cream, of special interest to the manufacturer; factors influencing the activity of Azotobacter in the soil; and the control of the tobacco hornworm and flea beetles.

The South Carolina station emphasizes the necessity for further investigations in regard to the value of southern crops in producing pork, with special reference to the avoidance of soft pork. Further studies are needed with grass and forage crops, and methods of developing pastures for beef cattle, especially the utilization of large areas of waste lands along streams and also of cut-over pine lands. South Carolina spends $50,000,000 a year for fertilizers, and studies should be made on the effect of different fertilizers on crops when applied to the various soil types of the State.

Among the various problems needing investigation at the South Dakota station may be mentioned those in crop pathology, forage crops in rotation, and permanent pastures; relation of sulphur in wool to the quality of the feed of the animal; enlargement of the operations in establishing hardy fruits for the Northwest; studies of the harmful and beneficial rodents and birds of the State; bee culture; cutworm control; fruit insects; and the insect parasites of domestic animals.

The Tennessee station reports that on account of lack of funds it will have for the coming year no horticulturist, no biologist, no veterinarian, and no meteorologist, and that work in animal husbandry has been cut to a minimum, although there are important demands in the State for information in all of these departments.

At the Virginia station work of all departments is suffering severely from lack of funds. Experiments along the lines of animal industry are inadequate and nothing is being done on animal diseases or in entomology. There is great need for investigation along the line of the economics of farming.

A large number of projects that should receive attention are mentioned by the Washington station, including the pocket gopher, field mice, and other destructive rodents; wilt diseases of forage crops; pasture studies; reclamation of alkali and tide lands; management of marsh soils; plant-food problems on cut-over land; water requirements of plants; horticultural by-products; the biennial fruiting of apples; strawberry and grape culture; various plant disease and insects; vegetable-seed production; degeneration diseases of potatoes; preparation of vegetables for storage; feeding work horses; range management; sheep diseases; factors affecting incubation and breeding of poultry; poultry housing under different climatic conditions; feeding problems of mature birds; cost of producing capons; alfalfa hays for milk production; standardization of ice creams and ice-cream mixtures; udder diseases; land drainage and farm-tractor power; cost of production studies with beef cattle, hogs, and sheep; farm leases and land tenure.

In West Virginia, the following projects demand attention: Value of buckwheat and fish meal as pork producers; buckwheat as part of the grain ration for breeding ewes; comparison of sunflower silage with corn silage for breeding ewes, two-year-old steers, and for milk production; pasture-improvement experiments; value of soy-bean hay and corn silage with home-grown grain; bacterial studies in cottage-cheese manufacture; the influence of a liberal supply of protein and ash constituents of animal origin in a ration for growing chickens as affecting the later fecundity of the females; the effect on the vitality of the embryo of holding eggs at various temperatures prior to incubation; bumble foot in poultry; infectious ophthalmia in cattle; social factors in rural community life; farm cost accounting; fertility experiments with truck crops; cultural experiments with apple trees; rôle of sulphur in vegetable crops; a study of hardy perennials and ornamentals; beekeeping; and fly control.

The subjects on which investigation is needed but wait on necessary funds at the Wyoming station are range investigations along both animal husbandry and agronomy lines; life-cycle studies of the sheep tapeworm; detailed studies of the common sagebrush, with reference

to feed value and products obtained by destructive distillation; a study of the therapeutic effect of drugs from typical poisonous plants; plant breeding; soil investigations; and the water requirements of Wyoming crops.

SOME RESULTS OF STATION WORK.

The work of the experiment stations has covered a wide range of subjects related to agriculture, and considerable progress has been made in many of them. A summary of some of the more outstanding results obtained is presented in the following pages:

AGRICULTURAL CHEMISTRY.

Studies in the relation of climatic conditions to the composition of cotton seed, at the Alabama station, show that a high rainfall in June, July, and August is accompanied by a high oil content. The North Carolina station finds that the toxic action of cotton seed, as a feed, can probably be overcome by heating with water, without the addition of any foreign material. An examination of Sudan grass for the presence of hydrocyanic acid, at the Kansas station, showed that if the grass is dried rapidly in the sun the poison can generally be found. After frost it soon disappears. The occasional cases of poisoning from Sudan grass are apparently due to liberation of the poison in the stomach through the action of an enzym which is very sensitive to the condition of the animal.

Investigations on the changes in composition of silage during fermentation, at the Iowa station, show that the total acidity, alcohol, and sugar, are entirely independent of the starch content of the silage corn, which remains constant throughout the fermentation process.

Chemical studies on the changes in composition of frosted wheat, at the Montana station, showed an increase in the nonprotein nitrogen, reducing sugars, and acid-reacting constituents. Milling and baking tests demonstrated the practicability of making good bread from prematurely frozen wheat. The Minnesota station finds that the glutens of flour are decidedly altered by drying, so that the difference between strong and weak glutens is then much less marked. Grain intended for seed should be stored in well-ventilated houses, while that which is intended for flour should not be ventilated. Extensive tests at the North Dakota station have shown that the true value of wheat for food purposes can not be determined by the physical characteristics that can be seen and sensed, nor has chemical analysis proved to be a true basis, although in many cases an increase in the nitrogen content of the wheat gives an increase in the volume of the loaf. The only basis appears to be the baking test. In a study of

substitutes, it is found that if more than 3 or 4 per cent of potato flour is added to wheat flour the volume, texture, and color of the loaf are noticeably lowered.

Much attention has been given to poisonous plants. At the Wyoming station the woody aster has been found to be most poisonous during the early stages of growth. The toxic principle has been isolated and is found to be neutralized by sodium carbonate, which indicates a possible treatment, but the practicability of such a remedy on the range is doubtful. Other poisonous plants which have been studied are the larkspurs, arrow grass, and lupines, all of which contain toxic principles, many having been isolated. Two larkspur species, *D. geyeri* and *D. barbeyi*, representing extreme habitats, were found to be quite closely linked from a chemical and physiological standpoint. The Colorado station has found a toxic glucosid in the whorled milkweed, most abundant in the leaves when the plants are coming into bloom. It is as poisonous when dry as in the green state.

The effect of alkali on Portland cement has been investigated at the Wyoming station, which finds that certain salts have an injurious effect, although acting rather slowly. Mixing the cement with weak sulphuric acid increased the alkali-resisting quality.

The peroxidase reaction has been found, by the Kentucky station, to be of value in seed-testing laboratories, for detecting nonviable seed, and for distinguishing between seed of high, medium, and low viability.

BOTANY AND PLANT PHYSIOLOGY.

The New Hampshire station, in a study of the growth of cereals, finds that there is not enough reserve of potash in the seed for normal growth and the symptoms of potash starvation appear early, the older leaves succumbing first, but the relative distribution of this element in the tops and roots is not affected by the quantity available. When potash-starved plants are supplied with the element, it promptly becomes distributed in accordance with the physiological needs of the plant. The amount of potash contained in a seed does not determine the length of time a plant grown from it can live in the absence of potash without injury resulting.

Studies on the nutrition of the fungus *Sclerotinia cinerea*, at the Minnesota station, confirm the theory that some substance similar to the water-soluble vitamin of animal nutrition is necessary for the normal development of the fungus. This vitamin is found to occur in considerable quantity in the juice of plums, peaches, and apples, in the sporophores of other fungi, in pollen and yeast, and its presence has been demonstrated in a great variety of other plant and animal tissues. There is some evidence of the necessity of two vitamins, one for vegetative growth and one for reproduction. The possible re-

lation of the vitamin content of the fruit tissue to disease resistance opens up an interesting field.

Studies of the permeability of plant tissues in the peach, at the Delaware station, show that the use of commercial fertilizers, in different combinations and amounts, results in a variable and selective permeability, not only toward salts used as fertilizers but toward other salts and organic compounds found in the tissues themselves.

The seasonal changes in most of the constitutents of fruit spurs are shown by the Missouri station to be distinct and characteristic of bearing, nonbearing, and sterile spurs. High starch and low nitrogen content at the time of fruit bud differentiation appear to be essential for productivity. Fruit-bearing spurs that develop leaf buds have a low starch and high nitrogen content and sterile spurs have a low starch and low nitrogen content. During the late summer and fall there is a steady increase in the phosphorus and nitrogen content of spurs with fruit buds, and the absence of this feature in sterile spurs suggests the necessity of the storage of these elements, preparatory to their marked increase, which is peculiar to bearing spurs in the spring, the fruit bearing of the spurs seeming to be dependent on this storage.

Investigations on the magnesium and sulphur nutrition of plants, at the Arkansas station, show that the oxid and carbonate of magnesium have a slight tendency to increase the oil content of the peanut and soy bean. Magnesium can replace the calcium in the leaves to quite an extent. It is also found that sulphur tends to increase slightly the protein content of the soy-bean plant.

Seed studies at the Michigan station showed the amount of combined water in some cases ran as high as 50 per cent of the weight, and the amount of water-soluble matter in dry seeds sometimes ran as high as 25,000 parts per million, apparently mostly protein. The Delaware station finds that the vigor, productivity, and food content of corn is quite closely related to reduction and oxidation processes of an enzymatic nature. A study of the nitrogen of legumes as cut for hay, at the Oregon station, showed that 30 per cent of the nitrogen in alfalfa is nonprotein, and of this, 10 per cent is amid nitrogen, 30 per cent amino acid nitrogen, and 60 per cent nonamino acid nitrogen.

BACTERIOLOGY.

Studies on the effect of woods and forest products on the bacterial activities in soils, at the Idaho station, showed that sawdust is toxic, cedar sawdust being most injurious and maple and ash least. All conifers showed an inhibitory action upon the nitrogen-fixing powers of the soil organisms. The addition of calcium carbonate to the forest soils improved conditions for nitrifying, ammonifying, and nitrogen-fixing organisms. Different species of soil bacteria were

found, by the Montana station, to vary largely in their response to arsenic, in forms used for insecticidal purposes, some of which compounds will kill most species outright, if applied in considerable strength, or if applied weaker, will inhibit or retard some of the normal physiological functions.

A study by the Colorado station of the natural inoculation of Colorado soils with legume bacteria, indicates this to be the case with alfalfa, sweet clover, and vetch, but that artificial inoculations are necessary for peas, beans, alsike, red clover, and white clover. The North Carolina station finds two distinct groups of organisms in the nodules of legumes. Eight distinct strains of *Bacillus radicicola* have been isolated from a number of native wild legumes of the State, by the North Dakota station. Indications are found by the Ohio station that nitrogen-gathering bacteria act in virtue of their ability to immobilize nitrate nitrogen by gaining the upper hand over the denitrifiers, rather than as active nitrogen gatherers. The New York Cornell station reports that certain algæ may fix amounts of nitrogen comparable with or larger than Azotobacter, provided nitrates are present; in the absence of nitrates, however, they apparently do not do this.

Chlorin, as chlorin water, was found, by the Arkansas station, to be rather effective against pathogenic organisms in milk, in concentrations that do not affect the odor or taste. Rats fed with milk so treated did slightly better than those on untreated milk. The Massachusetts station finds that the organisms occurring in canned peas, asparagus, and spinach are similar but not identical with *B. subtilis*. They can live with or without oxygen.

Studies on sterilization by pressure, at the West Virginia station, show that pressure up to 200,000 pounds per square inch is effective, and that the most delicate animal and vegetable material is not injured thereby.

GENETICS.

About 50 hereditary characters have been found in corn by the Connecticut State station, about half of which have been definitely located relative to the chromosomes. The New York Cornell station finds 8 distinct groups of characters, involving 20 or more factors, the factors within any linkage group being inherited more or less together but independently of those of other groups. In Blackhull White kafir the Oklahoma station finds 14 characters, some of which are units and some linked. Constant selection is necessary to hold them and the environment of the plant seems to influence all of the characteristics materially.

Important contributions in genetics have been made by the California station through studies of inheritance in tobacco, the work

being quite technical, but contributing important facts of general application. Crosses between a durum wheat and one of the common forms of emmer at the New York Cornell station have produced forms resembling the wild wheat or emmer of Palestine.

In a study of inheritance of characters in the apple by the Idaho station it was found that the color pattern of Ben Davis is dominant in all its crosses, while the tree characteristics of Wagner are also dominant.

In genetic studies with orthoptera of the genus Apotettix, at the Kansas station, as many as four different characters have been linked in a single individual so as to breed true, following strictly Mendelian segregation. It is believed that the same principles may be applied in the production of dual purpose breeds of cattle.

The Maine station, in studies on the inheritance of milk yield, has shown that high yield may be transmitted by either sex, that high yield is dominant to low yield, and that low butterfat percentage is recessive to high butterfat percentage. The inheritance of short ears in sheep has been investigated by the New Hampshire station by inbreeding short-eared animals, by which an earless strain was finally obtained. The presence of the short-ear character in one and of the no-ear character in the other parent gave lambs with short ears, but when the short-ear character was present in both parents an animal with no ears was produced.

It has been established by the Rhode Island station that egg weight is definitely inherited, and it should be possible to maintain a flock of hens laying eggs of uniform size by hatching chicks only from eggs of the desired type. The Maine station has shown that the linkage of egg production with the barred color pattern of the feathers in Barred Plymouth Rocks indicates a method of culling based on the feather color.

SOILS.

Studies on soil acidity at the West Virginia station show that for most field crops the optimum reaction is just below neutrality and that the harmful effect of soil acidity is due more to its depressing effect on the soil organisms than on the plant itself. Germination of the seed is less sensitive to acidity than subsequent growth. No relation was found to exist between the method of origin, the mineral composition, or the organic content of the soil and the intensity of their acidity. Heating increases the intensity of the acidity up to a certain temperature and then decreases it. Grinding decreases it in most soils, and it increases with decreasing moisture content. In general, the effect of organic decay is to decrease acidity.

The Oregon station finds that certain acid soils do not respond to liming as measured by crop growth. This was found to be due to

a lack of phosphorus, the addition of which increased nitrification and corrected the condition. A study of the hydrogen-ion concentration in solutions used for growing plants, at the Maryland station, showed that this is not a factor in plant development, no correlation of this with the growth being found.

Soil acidity studies at the Indiana station indicate that aluminum is a greater factor in causing toxicity than the hydrogen-ion concentration, and the addition of available phosphorus tends to lower the acidity by throwing the aluminum out of solution. The Michigan station finds that soils which react acid or alkaline to litmus fall into two groups, determined by the relation of the lime to the iron and aluminum. In all acid soils this relation was found to be above 1 : 1.3, while in all alkaline soils it was below this, 1 : 1.3 being the neutral ratio. The quantity of lime required to neutralize an acid soil may be determined by computing the amount of calcium oxid necessary to add to the acid-soluble calcium oxid in the soil to bring the ratio $CaO : Fe_2O_3 + Al_2O_3$ to 1 : 1.3. Studies on the use of gypsum at the Iowa station show that it has practically no effect on soil acidity and does not serve to replace lime.

Experiments at the Rhode Island station confirm previous results, that a high-magnesium limestone may be used as profitably as other forms of lime for correcting soil acidity. The Pennsylvania station finds that limestone, burned lime, and hydrated lime after two years gave practically the same yields when used in equivalent amounts. None of the three forms showed downward movement sufficient to correct acidity below the harrowed 3 inches of the soil. At the Rhode Island station corn made a rather chlorotic and abnormal growth where ground limestone had been added in large amounts, except when used in connection with Thomas slag phosphate, which contains much iron, or with large amounts of acid phosphate, which might aid in the assimilation of iron. The results indicate strikingly the deleterious effects of liming beyond the needs of a crop.

Investigations at the Oklahoma station on the effect of lime and manure on the impervious Kirkland upland soil, which comprises about 50 per cent of the State and which has a hardpan about $2\frac{1}{2}$ feet thick under 8 to 12 inches of surface soil, showed that the roots of alfalfa, with no treatment, did not penetrate the hardpan, with lime alone they went nearly through, with manure alone they penetrated through to the porous soils below, and with both treatments going still deeper. The lime itself did not move down into the hardpan. The treatment also stimulated the action of the ammonifying organisms and increased the development of the nitrifying bacilli. The application of manure increased the moisture in the soil, the effect lasting three years.

Analysis of a large number of Kentucky soils, by the station, showed that the best types contained the highest content of lime, the poorest having the lowest percentage. Cultivated soils showed considerably less lime than virgin soils. The application to low-calcium soils of a ton of limestone or rock phosphate per acre frequently adds more than is already present.

In extensive studies on the action and toxicity of soil alkali, at the Utah station, it was found that sodium chlorid and calcium and other sulphates first act in a stimulating manner, apparently connected with their effect on bacterial activity, through which nitrogen and phosphorus are made available. The favorable action of gypsum was found to rest largely on its chemical action on the soil constituents, especially iron and sodium chlorid. Chlorids and carbonates were most toxic, but this varied with conditions, carbonates being only half as toxic in sand as in loam. Organic matter tended to reduce the toxicity. Sagebrush is very susceptible to alkali and is a good indicator of its absence.

Attempts to reclaim alkali land by flooding, at the California station, showed that the drainage water was not taking off much of the black alkali (sodium carbonate). Chlorids and nitrates were found to rise faster by capillarity than black alkali. Conclusions reached on the management of black-alkali soils are that leaching is ineffectual as a means of washing black alkali from the soil. Large amounts of nitrates occur in the alkali, but always associated with still larger amounts of chlorids and sometimes of carbonates and sulphates. Toxic conditions are produced in such soils merely by adding sodium or magnesium salts, followed by leaching. In some cases, after removing the soluble salts by leaching, crops still made an extremely poor growth. Magnesium salts were more injurious than sodium, although the former leaves the soil fairly well flocculated, while the latter produces extreme deflocculation. Calcium salts, on the other hand, even when thoroughly leached from the soil, leave it in a condition highly suitable to the growth of plants. The Arizona station finds that 0.25 per cent of black alkali is near the limit for wheat, this amount diminishing the growth markedly. The limit, however, varies somewhat with the soil.

The results of five years' experiments with fertilizers in rotations, at the Iowa station, show that manure increased the corn yield 25 bushels per acre, and acid phosphate gave a further increase of 15 bushels. Similar gains were made with wheat, oats, and alfalfa. Soils at the West Virginia station, which had received heavy applications of fertilizer for 13 years, but none for the past 5 years, are still showing marked residual effects, especially those plats which had received acid phosphate, which are still producing twice as much

cowpea hay as the untreated plats. The Massachusetts station finds that ammonium sulphate may produce toxic compounds of manganese, aluminum, and iron, if these are present in the soil, and cause a chlorotic condition in the plant growth, but that abundant rains will leach them out.

Soil studies at the Michigan station show that soils may be cooled to $-4°$ C. and muck and peat to $-6°$ and $-8°$ without freezing. The amount of combined water in soils was found to be quite definite and not to vary with the moisture content. When water is added to a soil, some of it combines as water not containing any soluble salts, the result being a concentration of the salts in the soil sloution. In soils in a fine state of subdivision, the solubility in water is quite high at a temperature of 52° C., diminishing below this. Quartz and quartzites give the highest solubility at this temperature of any of the soil minerals. The addition of various salts to the solvent does not increase the solubility much.

Studies on the effect of fertilizer salts on the composition of the soil extract, showed that the silica in alkali soils is more soluble than that of acid soils. The solubility of the phosphorus was increased by practically all of the salts tried, and there was also a tendency to free sulphur. The amount of lime in the extract was increased by all of the materials tried, and this was true of the manganese to some extent. Iron, aluminum, potassium, and calcium salts increased the amount of sodium in the extracts, and the general effect of the salts tried (except those of potash) was to decrease the solubilty of the soil potash.

A study of the relation of soil moisture to balanced fertilizer rations, at the New Jersey station, showed no change in the physiological balance of the salts with different amounts of water, with the same amount of fertilizer, but by changing the amount of water there was a change in balance, resulting from a change in the concentration of the soil solution.

Investigations on the water requirements of various farm crops at the Washington station showed that the value of summer fallow lies not so much in conserving moisture as in making plant food available.

The Arkansas station finds that the ratio of carbon to organic matter in soils, may vary from 28 to 56, the general average being much below 58, which is usually taken as the conversion factor.

Some evidence is being obtained at the California station that green algæ were responsible for nitrogen fixation on the surface of the earth, in the first instance, and it is therefore probable that these, rather than Azotobacter, were among the earliest living inhabitants of the earth's surface. Experiments at the Montana station on the effect on nitrogen fixation of adding various salts showed that they

had but little influence in rich soils, but in poor soils the addition of phosphates was accompanied by an increase in nitrates, showing that they served a double purpose, acting as a direct plant food and as a stimulant to bacterial action whereby nitrogen may be oxidized and converted into nitrates. The largest increase in nitrates appeared in the continuously cultivated soils, the next largest being in the cultivated and summer fallowed soils, and the least in bare fallowed land.

A study on nitrates in soils, at the Missouri station, showed the crop to be the main factor in their removal. Early spring tillage increases the nitrates and a straw mulch of 10 or 12 inches practically inhibits their formation. The New York Cornell station finds that clover not only causes a larger increase in following crops than does timothy, but it leaves a larger amount of nitrate nitrogen in the soil, apparently having an accelerating effect on nitrification or contributing some easily nitrifiable material, although clover leaves the soil poorer in total nitrogen than some other crops. Plowing under large amounts of straw was found by the Washington station to depress the nitrogen content of the soil.

Studies at the California station, on the nitrogen nutrition of plants, showed that applications of nitrate of soda or sulphate of ammonia to soils deficient in available nitrogen, at certain stages in the growth of wheat, especially six or eight weeks after planting, is most effective in determining the gluten content of the grain.

Investigations at the Ohio station on the combinations and availability of phosphorus in soils shows that on an average one-third of this element in the surface soil and one-fifth in the subsoil, both virgin and cultivated, is in organic form, although there are large variations in the actual amount present in different soils. The reaction of the soil appears to be without influence on its quantity and nature. The phosphorus in this form is appraently not of a very high order of availability. It seems to bear a rather close relationship to the total organic matter and nitrogen. The Texas station finds that, as a rule, the phosphoric acid in surface soil is more available than that of subsoils and more so in nonacid than in acid soils. The phosphoric acid naturally contained in the Coastal Plains soil, as found by the North Carolina station, is more available and acts more efficiently than that in either the Piedmont or mountain soils. The limiting factor for profitable crop yields on peat soils is found to be lime.

The Wisconsin station reports that a study of the rôle that iron plays in relation to the phosphorus shows that as the amount of iron increases there is also an increase in the amount of basic phosphate, with a decrease in the crop. There are indications that the presence of lime prevents the phosphoric acid from going completely

over into iron phosphate. The addition of large quantities of acid phosphate did not increase the soil acidity, which is probably explained by the action of iron oxid, which is present in practically all soils.

Tests at the Illinois station show that plants are able to secure liberal amounts of potash from the shales, from deposits recently discovered in Union County. At the Maryland station, by composting greensand marl with manure and sulphur, 40 per cent of the potash was made available, but considerable acidity was developed. The Ohio station has made a study of the tendency of fertilizers and lime to increase the solubility of soil potash and also the effect of cropping on its availability, and concludes that while various treatments have little direct action on the potash-bearing minerals, favorable conditions for crop growth result, thus depleting the available supply. The soluble potash content of unfertilized soils is greater than that of soils where the treatment has caused increased yields. The Michigan station reports that the fixation of potash in soils is related to the calcium and magnesium and is the result of a chemical reaction. After leaching the fixation of potash is much diminished. The Tennessee station also finds by means of lysimeter studies that there is not only no liberation of soil potash by lime and magnesium, but that light, medium, and heavy applications of the carbonates effected a depression of the potash outgo.

Studies on soil sulphur, at the Tennessee station, show that magnesium salts cause a large increase in the formation and elimination of sulphates. Both elemental sulphur and iron sulphid readily oxidize to sulphates in the soil, without the aid of bacteria, and it is believed that the continued use of dolomitic limestone might eventually so deplete the soil of sulphur that it would become the limiting factor in plant growth. At the Ohio station applications of sulphur gave no indications that it increased the yield, but it did increase the acidity and the solubility of certain mineral constituents. Oxidation of soil sulphur was found, by the Michigan station, to go on most rapidly at 18° to 20° C. A small amount of sulphur, either elemental or combined, greatly stimulates the decomposition of peat and muck soils.

The California station finds that climate exerts a strong influence in modifying the soil flora, as was shown by studies of the same sample of the soil in different States. Methods of soil treatment also exert a marked influence, as shown by the Delaware station. The effect of manure is not always favorable, especially when applied shortly before planting, when it lowers the nitrates and increases molds and other detrimental organisms. The ammonifiers are increased largely by manure; the nitrifiers more by lime and phosphorus. An abnormal flora tends to reduce the yields of hay, clover, and grains. At the Missouri station samples of soils exposed to the sunlight and others stored for two

years in the dark both contained *B. radicicola* and produced nodules with legumes. Studies at the Utah station of bacterial activity show that this extends several feet into the soil, diminishing with the depth. The optimum moisture for ammonification was 60 per cent of the water-holding capacity of the soil, for nitrification 55 per cent, and for nitrogen fixation 70 per cent. Examination of a large number of soils by the Kansas station showed that only about 50 per cent contained Azotobacter and that this was associated with the absolute reaction. Soils in which the hydrogen-ion concentration was greater than 1×10^{-6} contained none, but if the acidity was neutralized it was readily introduced and established by inoculation.

The Mississippi station finds that there is a direct relation between the bacterial count and the amount of green-manure material added to a soil. The cumulative effect of the latter is marked. In one instance 8 tons of oat and vetch straw produced a larger crop than 20 tons of fresh horse manure. The Michigan station finds that Actinomycetes are largely reponsible for breaking down the cellulose of composted peat. Studies at the Massachusetts station show that tobacco not only reaches its best development on soils of medium lime requirement, but "tobacco-sick" soils infected with the Thielavia root-rot organism can be corrected by increasing the acidity.

The soil survey in Iowa has been supplemented by chemical analysis, pot and field experiments with each type of soil, and a careful record of practical results. Many farmers have applied the recommendations based upon these results, and reports show that in many cases the red-clover crop has been doubled or tripled by the use of manure, limestone, and a phosphate. Corn yields have frequently been increased to the extent of 10 to 20 bushels per acre, wheat shows increased yields on many soils that are very profitable, and the same results have been secured from other crops, as oats and alfalfa.

FERTILIZERS.

In connection with the great increase in the use of commercial fertilizers in Arkansas during the past year, the commercial authorities recognized the leadership of the experiment station and agreed to instruct the salesmen to advocate the use of such fertilizers as the experimental results indicated.

A study of the effects of weathering and storing on manure, at the Missouri station, showed the loss due to leaching is mainly in potash rather than nitrogen, the loss of the latter being more in the gases given off. The New York State station has been conducting experiments in composting manure with various substances, including straw, peat, rock phosphate, acid phosphate, and gypsum, and finds that a considerable loss of organic matter and nitrogen takes place,

except with the use of acid phosphate on peat. In culture experiments with these materials, using barley, fresh manure gave the best results, with the peat and acid phosphate composts next. Straw rotted with manure gave about the same results as rotted manure alone, the straw showing neither detrimental nor beneficial effects.

The value of applying sulphur with rock phosphate, if the mixture is inoculated with sulfofying bacteria, has been demonstrated by the Iowa station. The Michigan station finds that under anaerobic conditions a large percentage of rock phosphate can be rendered soluble when composted with peat and a small amount of barnyard manure as an inoculant. At the Georgia station raw rock phosphate composted with cottonseed meal gave a maximum availability in six weeks amounting to 3 to 5 per cent, but there was a loss of nitrogen as ammonia that offset the gain in phosphorus availability. Composting rock phosphate with sulphur, at the Virginia station, to render the phosphoric acid available, while showing a considerable increase in solubility, does not appear to be practicable for farmers.

At the Arkansas station it was found that on an acid soil the corn plant utilized phosphoric acid applied as rock phosphate, while the addition of lime to such a soil reduced the availability. The greatest availability of the rock phosphate was secured in sandy loam soils, with the addition of manure. The Florida station finds that a large proportion of the phosphoric acid applied in fertilizers is retained in the upper 9 inches of the soil. Experiments at the Maine station show that barium phosphate gives no increase in yield.

The Texas station notes a marked increase in foliage, growth, and yield in cotton from sulphur-treated plats.

Experiments have been conducted at the Maine station, on the effect of borax on potatoes, using varying amounts per acre, with and without watering. It was found that watering had little or nothing to do with the amount of injury. No normal plants were obtained in pot cultures where fertilizers containing boron were applied, all showing in varying degrees one type of injury characterized by a progressive drying out and death of the margins of the leaves, beginning at or near the tip of the older and lower leaves. Boron was found in the dead tissues. Similar bad effects were noted on beans, but very little on cereals and buckwheat. At the Indiana station it was shown that even small amounts of boron in fertilizers, drilled in the row with corn, injured the crop. From one half to 4 pounds per acre reduced the yield, while 16 pounds of anhydrous borax broadcasted did no appreciable harm. Similar tests at the Vermont station showed that borax up to one half pound per acre was not toxic and that there was a difference in crops in regard to the injury.

FIELD CROPS.

As a result of experiments on corn, cotton, and other field crops, at the Arkansas station, the Arkansas Seed Growers' Association has been organized and a pure-seed law passed.

The Utah station reports that manure applied to sugar beets at the rate of 10 tons per acre, gave an increased yield of about 1 ton of beets to each ton of manure. With potatoes manured at the rate of 5 tons to the acre, the yield was increased nearly 13 bushels for each ton of manure, but where 40 tons were applied the increase was only 4.3 bushels per ton. Manure applied to wheat gave an increased yield of 2 bushels for each ton where 5 tons was applied, 1.13 bushels where 15 tons was applied, and 0.33 bushel with 40 tons, the results with oats being about the same as with wheat. An average of nine years' application of manure to corn gave an increase of 3.83 bushels of grain and 428 pounds of stover, and 1.61 bushels of grain with 214 pounds of stover, respectively, for each ton of manure, when 5 and 15 tons were applied to the land each year.

Rotation studies at the Texas station demonstrated the inadvisability of winter or spring cover crops under conditions subject to late winter or early spring drought, on account of the reduction of available surface moisture, rotations that include a summer legume being much better. On rotation plats that have been running for 12 years at the Oregon station, where manure has been added, there has been an increase of 1½ per cent of organic matter and 50 per cent increase in crop production. A cover crop introduced into a rotation of wheat and potatoes, at the Kansas station, gave excellent results. Sweet clover was harrowed in the wheat in the spring and later plowed under for the potatoes. At the Maryland station, by sowing 10 pounds of sweet clover per acre in March, between two crops of wheat in rotation, about 9 tons of green manure were secured by the first week of August, this being found to be better than sowing the sweet clover in the stubble in the fall.

The Nebraska station has made extensive studies on the water requirement of crops. In tests on a large number of varieties of corn, a difference in total water requirement was observed, but there was practically no difference when based on a unit of dry matter. Sorghums required as much water, per pound of dry matter, as corn, while sunflowers required one-third more water. Increase of fertility results in an increase in water requirement through the larger size of plants and greater dry weight. The water requirement decreases with an increase in the density of the soil solution, until an optimum density is reached. Plants grown in soils low in fertility require an increased amount of water.

A study of the lodging of small grains, at the Ohio station, showed that quality is correlated with this character, poor quality going with stiff straw. Moisture and sunshine are also factors; with more of the latter, there is less lodging. A partial remedy would seem to lie in thinner planting. Varieties that stool largely are apt to lodge. Potash had no apparent effect in stiffening the straw. At the Wyoming station, early seeding of wheat, oats, and barley gave the best returns. Although the growth is slow at first they ripen earlier than later seedings. Barley has proved to be among the highest yielding and most profitable of the spring grains, at the Nebraska station. The California station has been instrumental in the introduction of Mariout barley, which exceeds in yield the common varieties at the station, and about 40,000 acres were grown the past year.

Much work has been done on wheat and a number of improved varieties and strains have been developed. At the Pennsylvania station, a superior selection, Pennsylvania 44, has been produced and is being widely planted, the demand for seed exceeding the supply. The North Dakota station has originated a variety, named "Kota" which is very promising as to yield, quality, and resistance to rust. Two selections of wheat have been secured by the Missouri station which are outyielding their parents by 8 bushels per acre. Three valuable varieties, Gladden, Portage, and Trumbull, which were originated at the Ohio station, continue to show increased yields and better quality of flour than the common varieties. Gladden is now in its thirteenth year and 50,000 acres are now being grown in the State, with 10,000 acres of each of the other two. Strains of Turkey Red wheat have been developed at the Nebraska station which yield $5\frac{1}{2}$ bushels per acre more than the commonly grown strains.

The Washington station has developed some very heavy-yielding hybrids, both of wheat and oats and is endeavoring to develop strains that will combine this quality with smut resistance, some of which give great promise of being successful. A strain of wheat secured at the North Carolina station and now distributed yielded 2.4 bushels more per acre than other varieties tested. Promising results are being obtained at the Maine station in selecting and developing a strain of wheat that will retain its hard quality in that State. Red Fife was found to produce the strongest flour and to give satisfactory yields. New and promising strains have been produced by hybridizing. A new and superior variety of durum wheat has been found by the Utah station, which has been named the "Sevier." Kanred wheat, which was first distributed by the Kansas

station in 1915–16, now has an estimated planting of 500,000 acres. It is being still further improved for hardiness and disease resistance.

In continuous wheat-culture plats, at the Oklahoma station, those receiving manure yielded 23 bushels per acre, compared with 13 bushels on the unmanured plats. The relation of rainfall to yield is found to be in inverse ratio in June, a heavy fall giving a decreased yield. Wheat seeded in furrows outyielded that broadcasted, at the Kansas station, and for five years there has been an increase of nearly 5 bushels per acre with the furrows running north and south over those running east and west, accounted for by the difference in sunlight. Late seeding of spring wheat (April) gave 14 per cent more scab than early seeding at the Illinois station. Six years' trial as to the effect of thickness of stand of wheat, at the Nebraska station, show no change in production in abnormally thick plantings, nor are the weaker strains eliminated. Practically the same results were secured by planting one, three, or five plants to a hill.

The Wisconsin station finds that both root and stem growth of wheat cease beyond a certain range of temperature. Old roots of winter wheat are practically destroyed during the winter and a new system develops early in the spring. Normal growth was found to occur best at comparatively low temperatures. The inorganic nitrogen content of the plant is increased at higher temperatures.

Results of investigations at the Washington station point toward the possibility of improving the milling quality of wheat by increasing the nitrogen content of the soil. Cost of production studies at the North Dakota station showed that it cost $2.75 to produce a bushel of wheat in that State in 1919. It is estimated, by the Missouri station, that 6,000,000 bushels of wheat were destroyed by the Hessian fly in Missouri in 1916. In that year a force was put in the field to demonstrate and explain its control, and through the cooperation of the farmers the damage is now very much reduced.

Tests with oats, at the Maine station, showed that in the northern part of the State medium early varieities are superior in yield to the lighter early varieties. An early strain of Fulghum oats has been produced at the Kansas station, which is giving high yields and is being multiplied for distribution. The Nebraska station has secured a strain which gives an increase of 7 bushels per acre. High-yielding hybrids have also been produced at the Washington station. A new and improved variety named "Idamine" is ready for distribution by the Idaho station; and the Iowa station has a new variety, the "Iowar," which outyields other varieties by nearly 9 bushels per acre. In an average of five years' tests at this station, oats drilled in rows 6 and 8 inches apart have yielded about 3 bushels more per acre than when drilled 4 inches apart. The Arkansas station finds that rate, date, and method of seeding are all factors in getting a

good stand of winter oats, rate being the most important. Date of seeding tests show the earliest safe planting to be the best for spring oats.

Cultural tests with buckwheat, at the Maine station, gave a larger yield by drilling than by broadcasting and less seed was required. An improved strain of sugar cane, Sc 12–4, developed at the Virgin Islands station, is being widely grown there and in Porto Rico. The station in the latter island is changing the varieties of cane generally planted to those immune to mosaic. By rotating sugar cane with legumes, at the Louisiana station, using sweet and crimson clover, sweet clover increased the yield of cane 6½ tons per acre.

A strain of alfalfa, bred by the Arizona station from a French variety imported by the U. S. Department of Agriculture, has outyielded all other varieties, giving an especially high yield during the hot summer months. The West Virginia station has shown that steep and stony areas, too rough for cultivation, can be successfully seeded to alfalfa, yielding satisfactory hay crops. Fall seeding of this crop gave the best results at the Tennessee station. The Kansas station reports an increased yield of 1,000 pounds of alfalfa from an application of 200 pounds of acid phosphate. Elemental sulphur was found to oxidize too slowly to be of immediate use for this crop, which requires 40 to 50 pounds per acre per season, as shown by investigations at the Washington station.

In a comparison of the relative value of alfalfa hay, cut at different stages of growth, at the Kansas station, the highest yield was obtained when cut in full bloom, giving 4.08 tons per acre. When cut in the bud stage the yield was 3.43 tons, and the stand runs to weeds and grasses in a very few years. The feeding value, however, was in favor of the bud stage hay, calves fed on this making the most rapid gains and consuming the least hay per pound of gain. Those fed on the hay cut in the seed stage made the smallest gains and consumed most hay per pound of gain.

The Tennessee station has been very successful in developing strains of Japan clover adapted to various purposes, as a tall, bushy variety for hay, a low growing, leafy variety for grazing, and one which will withstand low temperatures for higher altitudes. It promises to become an important forage crop for the State. Interest in the annual white sweet clover, which was developed by the Iowa station, is rapidly increasing, both for a green manure and a pasture crop. Growths of from 6 to 10 feet are reported from nearly all parts of the country. The best time for cutting vetch and wheat for vetch seed the Maryland station finds to be about three weeks after the bulk of the crop is in bloom. The Illinois station has established the fact that the Lima bean bacteria are identical, for inoculation purposes, with the cowpea group.

Corn improvement work at the Virgin Islands station has resulted in large increases in yield in the island. The New Mexico station has produced and distributed a strain of Mexican June corn, good for either silage or grain, with a small cob, bearing two ears, having a tight husk which excludes worms and which yielded an average of 82 bushels per acre. Tests on the productiveness of different varieties of corn at the Connecticut Storrs station has resulted in the establishment of a seed-growing center for Century Dent corn at New Milford. Eureka corn is reported to have produced 20 tons of silage material per acre, containing 8 tons of dry matter. Rustler's White Dent corn, as selected and improved by the Idaho station, is having a marked influence on the corn production of the State. A variety of corn which has been named "All Dakota" has been produced at the South Dakota station, which it is believed will ultimately represent a combination of high yielding characters in varieties successfully grown in the State. A difference in yield of corn as high as 40 bushels per acre has been found among varieties grown on the same piece of land, at the Missouri station.

Studies on corn fertilizers, at the Missouri station, gave an average net return from an application of 8 tons of manure of $22.04, from each ton of limestone $6.08, from 300 pounds bone meal $25.46, from 400 pounds of acid phosphate $19.56, from 1,000 pounds of rock phosphate $2.17, and from 50 pounds of potash $2.35. Corn studies at the Virginia station show a significant relation between yield and length and average circumference of ear, average circumference of cob, shape of ear, trueness to type, character of tip, uniformity and shape of kernels, and size of germ. The relation is slight between yield and ratio of butt to tip circumference, percentage of grain, number of rows, average length of kernel, character of butt, and space between kernels and between rows. A four-year rotation, of which three were in corn, has not proved very successful at the Illinois station. A comparison of the root systems of corn and sorghums by the Kansas station showed the latter to have twice as many small roots as the former, which enables it to withstand a limited water supply much better.

The Kentucky station finds that sound corn with not more than 12 per cent of moisture is not likely to spoil, and meal made from such corn can be kept in a condition suitable for human consumption from four to six months, provided moisture and air are excluded. This point is of special importance in the export of corn in the holds of ships. The saving of soft corn by salting has been quite successful at the Illlinois station.

The Oklahoma station has developed an improved strain of cotton, O–44, with a 1-inch staple and high yield, that is being distributed. Cotton breeding, selection, and hybridization, at the Virgin Islands

station, has produced four improved strains of Sea Island cotton, with exceptionally long staple and prolific bearers, one of which appears to be resistant to the blister mite. The Alabama station estimates that more than 50,000 acres of cotton are now grown annually from strains bred by the station, the reports from which show increased yield with a high percentage of lint, greater freedom from bud rot, and increased uniformity and earliness. The New Mexico station has demonstrated that cotton can be successfully grown in the State and the acreage is rapidly increasing. The Durango type is best, long staple cotton not maturing, but it is hoped to develop a strain of Egyptian cotton that will mature. The average yield for four years has been $1\frac{1}{4}$ bales of lint per acre.

Investigations as to the best method of growing cotton under boll-weevil conditions, at the Alabama station, showed that thick seeding, then harrowing the crop crosswise, leaving all the plants which remain, gives the best yield, the plants being thick in spots, causing early fruiting as a result of competition. Nitrate of soda was more effective as a fertilizer than other sources of nitrogen. The Missouri station secured a net profit of $8 per acre from moderate applications of acid phosphate on cotton, 300 pounds giving 100 pounds increase in lint. The Georgia station reports that the optimum application of fertilizers for cotton varies from 600 pounds of an 8–3–2 fertilizer on heavy clay soils to 600 pounds of an 8–3–6 on sandy soils. Studies on place variation in cotton, at the North Carolina station, carried on in cooperation with the Mississippi station, show that the Mississippi seed of the same strain gives a larger yield, is earlier, with a larger number of bolls, taller plants, and slightly longer lint than the North Carolina seed.

A study of the correlation of inherited characters in cotton, by the Texas station, showed that a high oil content goes with large seed and a low ginning percentage, the protein relation being in inverse ratio, high oil content going with low protein. There is found to be little correlation with yield. Investigations at the Mississippi station on the amount of natural crossing in cotton showed this to be from 3 to 8 per cent between adjacent rows and less than 1 per cent in rows separated by one other row of cotton.

Two strains of flax of high quality and resistant to wilt, have been bred at the Minnesota station. The Virgin Islands station reports very successful results in growing elephant or Napier grass, which has yielded 34 tons of green fodder per acre in 10 weeks' growth. It is being widely distributed over the islands. Similar favorable results are reported by the Porto Rico station. The Florida station has been quite successful in the introduction of Bahia grass in the State. Improved strains of timothy have been secured by selection at the New Hampshire station, and have been distributed.

At the Nevada station it is shown that in pasture lands drowned out by improper irrigation practices, the grasses change to worthless sedges, which can be corrected by adopting proper methods of irrigation. Studies on the effect of burning pastures, at the Kansas station, showed that while grass starts quicker after burning, there is not much difference at the end of the season, and there are less weeds in the unburned areas. Investigations at the New Mexico station have demonstrated the value of shadscale (*Atriplex canescens*) as an emergency range cattle feed. No bad effects were shown in cows kept on this pasture, although under certain conditions it is more or less poisonous to sheep. The Nevada station has found that sheep grazing on white sage should receive a supplement of from 2 to 4 ounces of concentrates (corn and cottonseed meal) per head. By this means, the loss of lambs was reduced 60 per cent. From 30 to 40 days' feeding is sufficient, and in favorable years it is unnecessary.

A number of poisonous range plants have been studied at the Nevada station, which has included feeding experiments to determine the lethal dose. This has included *Hordeum jubatum*, water hemlock, a milk weed, *Artemisia spinescens*, a Chrysothemus, three species of Solidago, two species of Tetradymia, several Delphiniums, aconite, and a Ranunculus. A saponin has been found in Atriplex which is poisonous to sheep at certain times, but not to cattle. Hydrocyanic acid has been found in arrow grass. The first tender shoots of the water hemlock (*Cicuta occidentalis*) are almost as poisonous as the roots, a few ounces being fatal. *Asclepias mexicana* is highly poisonous to sheep and cattle. Death camas is fatal only if eaten in large quantities, and causes but little loss. The results obtained by the Montana station in spraying with iron sulphate for the eradication of loco weed have been very satisfactory.

As a result of 10 years' work in potato breeding at the Utah station, selected seed has yielded 353 bushels per acre as compared with 184 bushels from unselected seed. At the Maryland station small seed pieces of the potato are found to produce spindling sprouts, the cause of which is not found to be evaporation, and chemical analysis does not show the removal of any definite substance in cutting that would account for it. It was also found that the addition of potato juice to a young potato plant acts toxic and diminishes the growth. After potato vines are killed by frost, unless the tops are cut off the big tubers become mothers for the little sets, which then develop at the expense of the big ones.

A study of the dormant period of potatoes, which lasts for about 90 days, during which they will not sprout, showed no change in composition during this period. The change from dormancy seems to be due to an exchange of gases, metabolic changes being at a standstill during this period. A study of the effect of using deformed

seed potatoes at the Colorado station indicates that it has little effect on the crop, the deformity being due chiefly to the ancestry of the tubers rather than to the condition of the individual seed piece. The Utah station finds that late plantings of the potato largely escape Rhizoctonia disease. Seed treatment with corrosive sublimate was effective for its control. It was found at the Wyoming station that the larger and fully developed plants gave the highest yields. Very little difference was noted between the stem and eye end of the tubers when used as seed. In spacing, the average weight of yield per hill increased directly as the distance apart of the hills in the row increased, but the total yield per acre was greatest with close planting, although the percentage of marketable tubers decreased.

A fertilizer low in potash produced the best seed potatoes at the Rhode Island station, but potato plats on which potash had been omitted entirely for 10 years yielded only 56 bushels of small tubers, whereas with a liberal amount of sulphate of potash the yield was 271 bushels. Tests at the New Jersey station show that the best time in the development to harvest the potato for seed is when approximately 50 per cent of the leaves were dead. Investigations at the Nebraska station indicate that under dry land conditions the yield of potatoes can be maintained for a long period if proper seed selection is practiced, while on the other hand the continued use of small potatoes, selected at random, reduces the yield. Potatoes that have been irrigated for one or more years show an increasingly higher percentage of degenerate strains.

Experiments at the New Mexico station have shown that the Irish potato is not a dependable crop in the lower and warmer portions of the State. A comparison of ordinary and cold-storage potatoes at the Rhode Island station showed very little difference in vitality. Tests of size and number of eyes in the seed piece showed that with the same number of stems, with the same amount of vines, the yield is not influenced by the size of the seed piece.

In experiments in storing sweet potatoes, at the Alabama station, it was found that a temperature of 25° F. did no harm to tubers that had been well cured by previous heating, but did to others. The loss of water in curing is about 4 per cent, the cured tubers being less corky, lumpy, and dry when cooked.

Extensive plantings of high land rice have followed its introduction by the Porto Rico station. In Louisiana about 3,000 acres of rice were seeded with varieties distributed by the station, with yields much above those obtained from varieties commonly grown. The demand for the improved seed exceeds the supply.

Tests of the rate of seeding soy beans with corn, for hogging off or for the silo, at the Indiana station, gave the best results from 5 to

8 pounds per acre. At the Missouri station a material growth of soy beans, by whatever method grown with corn, materially reduced the yield of the latter, except when planted late.

The Connecticut State station has developed a superior tobacco hybrid, a combination of Sumatra and Broadleaf, called "Connecticut Roundtip." Wide variations were obtained at the West Virginia station in the yield and quality of tobacco from different fertilizer treatments, manure and acid phosphate giving the highest net returns. Studies on the concentration of nitrate of soda tolerated by tobacco, at the Kentucky station, indicate that when this is greater than 1 part in 3,750 parts of water the plants wilt, but will recover from strengths up to 150 parts, above which growth was prevented and the plants die. Experiments in the curing of Burley tobacco show that as high grade leaf can be obtained by flue curing at a relatively low temperature as by air curing, thus eliminating completely the danger of house burning.

Montgomery seed-leaf tobacco, which was originated at the Ohio station, is now having a world-wide distribution.

HORTICULTURE.

Both the Maine and the Pennsylvania stations note that yield of apples is closely correlated with trunk circumference and more loosely with rapid growth, and that this measurement may also be taken as an index of the effect of fertilizers. The type of tree is also a factor in yield, which is true even within the same variety.

At the Ohio station, in fertilization experiments on apple orchards, in Washington County, nitrogen alone gave as good results as a complete fertilizer. Contrary to the general belief in the peach-growing sections of the State, applications of nitrogen not only did no harm but improved the yield. In a long series of experiments in orchard practice at the New Hampshire station, fertilized trees are just beginning to show increased yields over the unfertilized ones, after 12 or 14 years. When a nitrogenous fertilizer had been used, the yield was 83 barrels of apples, with a combination of phosphorus and potash 50 barrels, and where no fertilizer had been applied 45 barrels.

Apple trees under tillage have done much better than untilled trees, and the value of this practice has been established. Clean cultivation is giving better results than cover crops in the orchard, at the Illinois station. In a comparison of the advantages of mulching and cultivating at the Ohio station, the conclusion is reached that this depends on the soil and conditions, mulching giving better results on a dry soil. At the Indiana station, trees under tillage and cover crops made 45 per cent more growth and produced 11 times as much fruit as trees in sod. Tillage and straw mulch were superior

to grass mulch. In a young fruit orchard of apples, cherries, and plums at the New York Cornell station, cultivated trees grew better than those in sod, and fertilizers appeared to have no effect on the latter. There was found to be less soil moisture and less fixation of nitrogen in the sod plats. Good results were obtained in the renovation of prune orchards, at the Washington station, by the use of manure and cover crops.

Pruning was found to be a dwarfing process at the Indiana station, causing the trees to come into bearing later. The root system is found to be dwarfed even more than the tops. Lightly pruned trees made 48 per cent more growth than heavily pruned ones. The New York Cornell station also reports that any considerable amount of pruning reduces the leaf surface, delays fruiting, and reduces production. Similar results were obtained at the Massachusetts station, where improved trees made the largest growth in girth of trunk, which diminished with the amount of pruning. A comparison of trees pruned during the dormant period, in February and in June, at the Nebraska station, showed a greater rate of growth in the former. Pruning experiments at the California station have more or less revolutionized the practice in the State. Long pruning gave a much better growth of tree, with higher yields, in some cases from 50 to 100 per cent higher, than short pruning. Pruning by thinning out gave better results than heading back, the latter causing an abundance of sucker-like growth. Pruning studies at the Oregon station were directed to the effect on the physiological activities of the tree.

In apple pruning experiments at the New Jersey station, the pruned trees have yielded more and better fruit than the unpruned ones, and the beneficial effect on the general condition and shape is noticeable. Defoliation was found to disturb the carbohydrate-nitrogen ratio and to throw fruiting spurs into vegetative growth. A close correlation was found in certain varieties between the total leaf area removed and the size and quantity of fruit produced. Similar studies on the tomato showed that the fruit production in this plant is dependent on the carbohydrate-nitrogen supply of the whole plant and not of the fruiting spurs only, as in the apple. A severe removal of the foliage prevents the development of the fruit, even when blossoms are abundant. In the apple, the general appearance of the leaves was found to be a very good index of the vigor of the tree. Results obtained at the Virginia station confirm that of others, in that summer pruning of the apple retarded growth, delayed fruiting, and was especially harmful as regards fruit-bud formation.

A comparison of spraying and dusting, at the Virginia station, showed that dusting with mixtures of sulphur and lead arsenate was

effective for controlling curculio, codling moth, and peach scab, but it did not control bitter rot of apples and brown rot of the peach, and was of doubtful value in apple scab. Standard methods of spraying paid good dividends on the cost, even with the least efficient sprays, at the Maine station. At the Illinois station, a study of the cause of the drop in pressure between the pump and the nozzle in spray apparatus showed that this is greater the larger the nozzle opening, and that couplings also cause a loss.

Much progress has been made, at the South Dakota station, in securing new hardy varieties of fruit from the extreme north, to be used in developing hardy varieties for the Northwest by cross-pollination. Grape cuttings have been secured 200 miles farther north than had previously been reported.

The Arkansas station has definitely shown that the set of fruit depends largely on the vigor and abundance of the pollen, and that the size of the fruit is closely correlated with the number of well-developed seeds, which are, in turn, dependent on the abundance and vigor of the pollen. Plats receiving nitrogen showed a decided increase in pollen vigor. On plats with an excess of nitrogen the fruit was deficient in color. Fruit spurs were modified in vigor and performance by the general vigor of the branch and their position upon it.

Studies of factors affecting the setting of fruit of tomatoes, at the Oklahoma station, indicate that falling of the blossoms is due largely to imperfect pollination and that moisture is also a factor in the setting of the blossoms. The loss of peach buds during the winter is apparently due to a weakened condition and is a nutritional problem. High cultivation resulted in better development of fruit buds, especially with peaches, at the Virginia station, and also gave larger yields of fruit and better growth of trees than either low cultivation or sod.

Studies on fruit-bud formation under different systems of orchard management, at the Iowa station, indicate that apple trees on clover sod and on cultivated plats tend more toward annual bearing, while on the bluegrass-sod plats they are biennial bearers, which may be explained by the fact that the former made sufficient annual growth for the formation of fruit buds on the younger portion of the trees, the older fruit spurs being very irregular bearers. The studies indicate the possibility of producing annual bearing trees by proper orchard management. Investigations on the influence of light on fruit-bud formation, at the New Hampshire station, showed that in the shaded trees the leaf area was larger, but branching and fruit-bud formation was much less than trees growing in sunlight, which probably explains why dense unpruned trees do not flower in the interior of the tree. The Utah station finds that the amount of injury to

fruit buds by freezing is influenced by the concentration of the cell sap.

A very valuable hybrid of the dewberry and raspberry has been produced at the Texas station, with fruit of fine quality, which is self-fertile and which readily crosses with other species of Rubus. The fruit is larger than that of either parent, of a dark red color, and intermediate in flavor. June drop, which is very common in the State, was found by the Washington station to be due to incomplete fertilization.

Studies on winter injury at the Nebraska station show that as a rule the root system coming from the stock was killed, while that from the scion wood withstood freezing temperatures, the results suggesting the advisability of propagating fruit trees in such a way as to get the major portion of the root system from the scion wood. The investigation has brought out some interesting data as to the rooting habits of various varieties of apples, in some of which the scions root readily the first year, others requiring two or three years, and some not rooting at all. The handling of perishable berries by freezing has been quite successful at the California station.

Stock and scion studies with the apple, at the Massachusetts station, show that Oldenburg and Northern spy roots have a decided dwarfing effect. The Baldwin seems less hardy on its own roots than on some others. Results of a study of the factors influencing the biennial bearing of apples, at the Maryland station, show that a spur which blossoms but does not fruit will probably blossom again. If it does not set fruit up to the June drop, it will bear the next year. Two groups of blossoming spurs can be distinguished, one of which will blossom the next year, the other not. Those making the largest growth with the most leaf area blossom. Spurs which make a growth of 2 millimeters or less do not bloom, with 4 millimeters they bloom but do not set fruit, with 6 millimeters they bloom and set fruit, and longer ones become vegetative. Attempts are being made to control these by fertilization, pruning, and cultural methods.

The Delaware station finds a close relation between the health and vigor of apple trees and injury caused by spraying materials. Spray injury symptoms can be used as an indicator of fertility starvation in apple orchards. In studies in apple storage at the Washington station it was found that the summer temperature had little influence, but the temperature at the time of maturity and during the harvesting of the fruit is very important.

Cowpeas proved to be the best cover crop in the citrus grove, at the Arizona station, and it was found to be good practice to sow alfalfa in the grove in the fall. The Florida station finds that the use of ground limestone and Thomas slag causes injury in the orange grove, indicated by frenching. Clean cultivation throughout the

year was of considerable benefit to young trees, but after a few years leads to a loss of soil nitrogen. It is not a desirable practice with trees over five or six years old. At the California station, a cross between a paper-rind orange and a grapefruit has been obtained, the result being a grapefruit with a very thin skin and a juicy, firm pulp.

Investigations on hardiness of the peach, at the Maryland station, show a marked seasonal increase in the water content of the fruit buds of certain varieties, the difference becoming more marked as the season advances. In those varieties considered the most hardy the ratio of water content to dry weight of fruit buds is less than in others. Nitrogen and potash gave striking results, both in growth and yield, in the peach orchard at the Alabama station.

The Arizona station is developing a species of tamarisk from northern Africa, which is very ornamental, of rapid growth, tolerant of strongly alkaline soils, and with hard and durable wood. At the Illinois station, applications of acid phosphate in the greenhouse gave about 5 per cent increase in flower production for two or three years without further applications.

A number of superior strains of beans which breed true have been isolated at the Maine station. These surpass in size, appearance, and yield, any now on the market. The Porto Rico station has been successful in its efforts to encourage a greater production of beans for home consumption. The importance of phosphorus in the fertilization of early cabbage on Hagerstown clay loam has been demonstrated by the Pennsylvania station, nitrogen, and to a larger extent potash, giving very slight returns, the results pointing the way to both better yields and more economical fertilization. Applications of 3,000 pounds of lime per acre, at the Rhode Island station, were successful in preventing club root of late cabbage following spring crops. The New Mexico station has produced an improved variety of chili (No. 9), which has a large, smooth, tapering pod, fleshy, and with no shoulder at the stem end. The Ohio station has developed strains of lettuce that are not very susceptible to tipburn, which has been giving considerable trouble in the State.

The Tennessee station has been very successful in developing a Fusarium-wilt resistant tomato. Grown on wilt-infected soil, 86 per cent of the plants were free from wilt and all matured a good crop. Selections have kept their resistance for 10 years. Similar successful results have been obtained at the Illinois station. Striking results have been obtained at the Missouri station, in fertilizing tomatoes. Phosphates gave the best returns, often doubling the yield and causing early maturity. The fertilization of tomatoes proved profitable at the Indiana station, 500 pounds of a 2–12–6 fertilizer giving a net profit of $44.45 per acre. Similar results were obtained at the New

Hampshire station, demonstrating the value of phosphorus for this plant.

Studies in metabolism in sweet corn, at the Maryland station, indicate that a distinction should be made between the ripening and maturing stage, the latter being a drying-out process. The total nitrogen and fiber early become quite constant, the principal changes after this being in the carbohydrates, in which the starch increases and the sugar falls off. The best edible period lasts only two or three days with the early varieties. The corn is ripe when the constituents have attained an equilibrium.

FORESTRY.

At the Iowa station, after 15 years of service, fence posts from common Iowa woods that were creosoted are still serviceable, while the same posts uncreosoted lasted only from three to five years. By this treatment the inferior, soft woods of the State can be used for this purpose. In a study of insects attacking freshly cut wood, especially pulpwood, at the Minnesota station, it was found that shading the logs during the summer will prevent the development of some species and the ovipositing of others. Logs that have been stored in water for a time are less subject to attack when removed from water and dried than those that are stored dry.

DISEASES OF PLANTS.

Promising results are being obtained at the Michigan station in the differentiation and determination of different strains and varieties of pathogenic fungi, especially Fusaria and Phoma, by the biologic test, in which rabbits are sensitized and the anaphylactic reaction noted. About 30 species of Fusaria that are often hard to distinguish, except by the biological method, attack potatoes.

The Wisconsin station finds that soil temperatures influence seedling infection with fungus and bacterial parasites, although the range is quite wide. Wheat seedlings are found to be subject to attack by the wheat-scab organism between 3° and 30° C. and corn is subject to attack at still lower temperatures. In studies of the relation of time of planting to disease, less disease was found on late-seeded winter wheat, early-sown spring wheat, and late-planted corn.

The Texas station has isolated the causal organism of the black mold of ear corn. Infection takes place only in the milk stage, and thin-husked varieties are most susceptible. The same fungus attacks other hosts, causing rots of squashes, peaches, and plums. In studies on the root and stalk rots of corn, at the Indiana station, the primary trouble was found to be, in many cases, an accumulation of metals, mainly iron and aluminum, in the nodes, which, in undergoing oxidation, destroy the normal conditions, weakening the roots

and rendering them susceptible to the attack of rot organisms. Limestone and acid phosphate applications appear to remedy it. Studies of corn root rot at the Missouri station show that seed is commonly infected, often in an apparently healthy ear. The Kentucky station finds that practically no seed grown in the section was free from infection with the organism causing this rot, *Fusarium moniliforme*. Infection was found to take place before the late milk stage and apparently occurs through the silk. Selection of resistant strains seems to be the only means of control and has been attended with some success.

A severe epidemic of corn rust on the breeding plats, at the New York Cornell station, showed that most North American varieties of dent, flint, flour, pop, and sweet corn are susceptible, while practically all of the South American varieties are highly resistant. The red-rot fungus of sugar cane (*Colletotrichum falcatum*) was found, by the Louisiana station, to be the principal cause of poor germination.

The Texas station reports that the cotton-wilt organism will attack okra, but a new okra Fusarium was found that will not attack cotton. A definite relation was found between temperature and wilt, the most favorable being likewise so for the host. With proper drainage good results were obtained in the control of Texas root rot as it affects cotton, by rotation and deep plowing. It has a large number of hosts. Temperature and moisture are the controlling factors. The successful control of angular leaf spot and anthracnose of cotton has been secured at the Arkansas station by delinting, and at the South Carolina station by keeping cotton seed three or four years before planting, the latter method now being quite generally practiced. The North Dakota station reports that evidence has accumulated that wilt resistance in flax is a permanent quality that may be transmitted and increased.

Studies of cereal leaf rust, at the Indiana station, show two distinct strains. The genus Thalictrum, of the Ranunculaceæ, appears to be the common alternate host in upper central Europe, but in this country the rust apparently lives over on wheat only. There is considerable variation in the resistance of varieties of wheat to this rust. It is specific and is not identical with any of the characteristic grass rusts, although several species of grasses and grains have been found on which it will grow weakly.

In breeding for resistance to stem rust in wheat, at the Minnesota station, hybrids have been obtained that are quite resistant to at least two biologic forms of the fungus, while neither of the parents were resistant to both.

The Idaho station finds that smut infection of wheat increases with increased moisture content of the soil at planting time. Culti-

vating summer fallow was found to increase the percentage of smut in the subsequent wheat crop.

The Iowa station reports that the Septoria leaf spot of wheat survives in the imperfect stage the period from harvest time until the rosette stage of winter wheat. Mature pycnidia were found in volunteer and winter wheat seedlings as early as October 2 and November 1, respectively.

The Virginia station finds that nematode disease of wheat may be controlled by the use of clean seed and crop rotation. Studies of wheat diseases at the North Dakota station, show that both Fusaria and Helminthosporium, a number of strains of which have been isolated, are commonly seed-borne, emphasizing the value of seed treatment and selection.

The Iowa station finds that crown rust of oats also attacks a large number of grasses in at least nine genera, on which it is probably carried over winter or which serve as intermediate hosts.

Investigations by the Maine station on the transmission of potato mosaic showed that this may be done by means of tubers, grafting, the plant juice, and aphids, but attempts to transmit it through flea beetles, potato bugs, the seed-cutting knife, contact of seed pieces, roots, and vines were unsuccessful. All indications are that it is a parasitic disease, and plant lice are evidently active agents in its spread. For its control, spraying for plant lice, early harvesting of potatoes intended for seed, and isolated seed plats for disease-free seed are recommended. Good success has attended efforts to produce seed free from the disease. Leaf roll is also a virus disease and is apparently transmitted by insects, and while it is more destructive than mosaic it does not spread so rapidly. There are indications that this disease and net necrosis are closely related if not phases of the same disease, as tubers with net necrosis are likely to produce plants with leaf roll, although the reverse is not true.

Studies on the viability of the potato blackleg organism indicate that in Maine the bacteria do not live over in the soil, due to the fact that they can not survive after being separated from the host plant. Spraying with Bordeaux mixture for the control of late blight of potatoes, at the New Hampshire station, indicated that used in amounts sufficient to supply about 25 pounds of metallic copper per acre, applied in weekly or fortnightly sprayings, the mixture gives absolute protection.

The Vermont station finds that potatoes grown in newly cleared land from disinfected seed, with artificial fertilizers only, give only about 2 per cent of scab, indicating that the organism occurs commonly in the soil. The New Jersey station reports that the use of elemental sulphur for the control of this disease, when applied at

the rate of 300 to 600 pounds per acre, more than doubled the percentage of clean tubers with some increase in yield.

Studies on the spread of Verticillium wilt through the soil, at the Oregon station, indicate that this is at least 15 inches in a single growing season. Its entrance in the host plant is apparently through the root and it seems to be commonly associated with Fusarium wilt. The Idaho station reports that in the control of Rhizoctonia disease of the potato by treating the seed with corrosive sublimate it is found that different amounts of this material are absorbed from the solution by different varieties of potatoes.

Speck or wildfire of tobacco is found by the North Carolina station to be carried over in the seed, the soil, and the cloth covers used on the tobacco beds. For the control of this disease, as well as angular leaf spot, the Virginia station obtained good results by sterilizing the seed with formaldehyde solution, sterilizing the cloth coverings, and locating the seed bed on new land, and the Kentucky station found an effective means of preventing infection was covering the seed pods from flowering time on. Studies on the control of root rot of tobacco, at the Ohio station, show that steaming the seed bed is the most practicable method. The bacterial blight of soy beans is found, by the North Carolina station, to be seed borne and that preventive measures lie in seed treatment.

Studies at the Maryland station on the control of Sclerotinia fruit rot, which also attacks buds and blossoms, show that dusting or spraying with lime sulphur and Bordeaux, if done early, will control it in the blossoms, after which there is not much trouble until the fruit gets ripe. The Delaware station finds fire blight is related to winter scald, which results from the exposure of the roots at the base of the trunk, from which varying degrees of sun scald and winter scald result. Banking the stems appears to reduce sun-scald injury.

In studies of apple diseases, the Oklahoma station found that three sprayings gave absolute control of blotch. These should begin as soon as the petals drop. Studies on this disease at the Indiana station showed that winter spraying with lime sulphur gave no control. Bordeaux dust gave 31 per cent of clean fruit, sulphur dust 53 per cent, and Bordeaux spray 60 per cent. For summer spray, however, lime sulphur was found to be about as good as Bordeaux. A prebloom spray of strong Bordeaux mixture was successful in controlling scab, at the Ohio station.

At the Iowa station, blister canker was well controlled, on hardy trees, by removing the infected portion with a gouge and mallet and painting the wounds with a lead paint containing 1 ounce of powdered mercury bichlorid to 2 quarts of paint, the bearing life of the trees being prolonged several years thereby. The Arkansas station finds that

new trees may be planted in orchards where others have been killed by blister canker without danger of infection through the roots.

At the Virginia station, studies on the susceptibility of Northern Spy rootstocks to Xylaria, causing black rot, indicated that while they possess a considerable degree of resistance and are superior in this respect to the ordinary seedling stock, they are not wholly immune to infection. Preliminary studies of the physiological characteristics and behavior of varieties differing in susceptibility indicate that there is a significant relation between carbohydrate transformation and susceptibility. Investigations on apple rust, at the West Virginia station, show that leaves become immune in from 10 to 28 days from the time they unfold. The eradication of the red cedar has proved to be a very effective means of reducing the disease.

The New Jersey station reports perfect control of the cherry leaf spot by spraying with lime sulphur, like success being secured by the Wisconsin station by proper sanitation, such as plowing under or disposing of the dead leaves, with two sprayings of Bordeaux or lime sulphur.

At the Florida station, all investigations have failed to give evidence that gummosis of citrus trees is due to any parasitic cause. A causal organism of gummosis of the lemon in California, however, has been identified by that station, and successfully controlled by removing the earth from the trunk and, in several cases, by painting with Bordeaux paste.

Citrus blast was found to be prevalent in all citrus groves north of Sacramento. It is most active in cool, moist weather. Bordeaux mixture was found to be quite effective in its control. A striking difference was found in the mineral constituents and nitrogen in the leaves of citrus affected with mottle leaf and healthy leaves, the former being high in potash, phosphorus, and nitrogen and low in calcium. There is evidence that excess of soluble sodium salts in the soil lowers the soluble lime; thus the nature of the soil solution is an important factor in the disease.

The Florida station finds a close connection between melanose and stem-end rot. Dripping of water or dew from twigs infected with melanose, or fruiting bodies of the organism taken from dead twigs and inoculated into the fruit, readily produce stem-end rot. There are indications that in the first stage of the growth of the fruit there is a susceptibility to melanose spotting, followed by a stage of apparent immunity to both melanose and stem-end rot, and a final stage of susceptibility to stem-end rot and immunity to melanose spotting.

It is believed, at the Florida station, that a fungus of the Cercospora type is responsible for the spotting disease on avocado, which is

sometimes called avocado blotch, frequently associated with Colletotrichum. Both black spot and blotch were effectively controlled by two sprayings with Bordeaux mixture, which is also effective against the scab on this plant. All attempts to control pineapple wilt by soil disinfection were unsuccessful, the only remedy appearing to be in finding resistant strains. A new rot of date fruit, which is becoming serious in Arizona, was found by the station to be caused by an initial attack of an *Alternaria* sp. followed by Aspergillus and Penicillium, the result being a mummifying of the fruit.

In studies on peach yellows, at the Delaware station, bud grafting from a diseased to a healthy tree transmitted the disease, but emulsions prepared from affected trees injected into healthy ones gave negative results. The value of a lime-sulphur dormant spray in controlling leaf curl was demonstrated. The Marietta plum and a peach were found by the Georgia station to be resistant to root knot, and may prove valuable stock for propagating. Sulphur dust was very effective for the control of scab and quite so for brown rot of the peach, at the West Virginia station. Good control of the pear fruit and leaf spot was secured at the New Jersey station by spraying with either Bordeaux mixture, commercial lime-sulphur, or self-boiled lime sulphur. They all caused slight injury except the last one, which was, however, slightly inferior. Perfect control of raspberry anthracnose was obtained at the Iowa station by the use of lime-sulphur solution.

The Connecticut State station has made extensive studies on the white pine blister rust and has determined the channel of infection, its progress and development. The Minnesota station finds that its control lies largely in the eradication of wild currants and gooseberries.

A satisfactory method of controlling bean blight, at the Oklahoma station, was found to be in storing the seed for two years, which absolutely destroys the blight and decreases the germination but slightly. The Michigan station finds indications that bean mosaic may be transferred by aphids and leaf hoppers, and that it is also seed-borne.

Some success has resulted from breeding work with cabbage for resistance to yellows, at the Ohio station. Similar success has been obtained at the Iowa station, where selected strains have given a field stand of 78 per cent, as against 36 per cent from commercial seed. Excellent strains of kraut cabbage that are resistant to yellows have been produced by the Wisconsin station. This station finds that blackleg is due to an internal infection of the seed, which is not controlled by ordinary seed treatment, emphasizing the necessity of careful seed selection.

The causal organism of chili blight has been found by the New Mexico station, and named *Fusarium annuum*. Its activities are closely related to the soil moisture, it being no longer troublesome when this falls below 12 per cent, which suggests a method for its control.

The Michigan station finds that the sunflower is a host of cucumber mosaic. Attempts to control eggplant blight by spraying have not proved very successful at the Louisiana station. The wilt of this plant was controlled by seed-bed sterilization and crop rotation at the New Jersey station.

At the Iowa station, downy mildew of lettuce was effectively controlled by applications of Bordeaux mixture. The disease is found to be prevalent in wild lettuce, and the eradication of this is therefore an important sanitary measure. At the Kentucky station, failure in growing head lettuce in the greenhouse was found to be due to a Fusarium, the only remedy for which seems to be soil sterilization.

The Texas station finds pink root of onions to be caused by a species of Fusarium and to be carried over in the soil. It is widespread over the United States. The Georgia station reports that pepper mosaic is distinct from that of the wild pokeweed, and is not soil-transmitted. A new Fusarium was found on squash by the Texas station. Studies at the Delaware station on sweet-potato pox, which is a serious trouble in the State, show it to be transmitted by infected soil, and can not be corrected by applications of manure and fertilizers, its control probably lying in rotation. It also attacks white potatoes.

Considerable work has been done on tomatoes. The Ohio station has been quite successful in developing strains resistant to Fusarium wilt, Septoria, and fruit rots. The Maryland station has developed strains which are being widely grown and show no signs of losing their resistant character. It is found, at the Georgia station, that infection occurs most commonly through any of the softer tissues of the plant, the fungus not being able to penetrate mature cell walls if they are at all thickened. Studies at the Maryland station show that tomato blight is not seed-borne, but is disseminated mainly by wind and water. It lives over winter in the soil in the Septoria stage and spreads quickly in rainy weather. Spraying and early maturity were found necessary to control Alternaria early blight at the Texas station. Studies on winter blight, at the Pennsylvania station, indicate that while the initial infection is from diseased seed, the common methods of pruning and handling the plants, as well as the common insects, as the white fly, are instrumental in spreading the disease in the greenhouse. At the Indiana station, tomato

mosaic, which causes serious damage in the State, is found to live over winter in the rootstalk of the ground cherry. A new bacterial disease has been found, causing black, scabby spots on the fruit. The causal organism is carried over in the seed, and successful control was secured by treating these with a 1 to 3,000 solution of mercuric chlorid for 5 minutes.

Three distinct species of Fusarium were found in the wilt of watermelons at the Texas station, two being new ones that will only attack this plant. The causal organism of anthracnose was found to attack other cucurbits. It causes serious damage in wet seasons. Spraying with Bordeaux gives promise of its control. The organism causing stem-end rot was identified as being probably the same as that causing a rot of sweet potatoes.

ENTOMOLOGY.

A study of insecticides at the Oregon station showed that acid preparations were more toxic than neutral or alkaline A dilution of 1 pound of acid lead arsenate to 400 gallons of water was effective for small tent caterpillars and probably others. The commercial lead arsenate was found to be the nearly pure acid salt, the powder form being physically superior to the paste. Tests show that the addition of a spreader increases the efficiency very much, for which purpose calcium caseinate, glue, gelatin, or oil emulsion may be used. Calcium arsenates were found to have a high killing efficiency as a poison spray for chewing insects. Nicotin sulphate was found to be very effective. At the Washington station the best results with lead arsenate were obtained with a strength of 1 pound to 75 gallons of water. A study of the insecticidal properties of the pine oils and creosotes, at the Maryland station, show the most volatile fractions to be the most active, the residues being practically worthless. The Pennsylavania station, in a comparative study of dusting materials containing definite percentages of nicotin sulphate and the liquid spray, found that the results were strongly in favor of the liquid application.

Bee studies, at the Kansas station, show that if satisfactory methods of wintering are practiced, losses are very much diminished and the production of honey is materially greater, best results being obtained by the use of windbreaks and packed two-story hives. To prevent the introduction of foul brood in bee colonies, the Wisconsin station recommends that hives and frames be scraped and thoroughly washed with hot lye water instead of scorched, as is usually done.

The codling moth was well controlled, at the Connecticut State station, by dusting with sulphur and lead arsenate, and red bugs by adding nicotin to the dust. Soap and strong lime-sulphur sprays were promising in controlling the European plum moth. At the

Delaware station magnesium arsenate has given results equal to those given by lead arsenate in codling-moth control and with little, if any, injury to foliage. The moth was found to be attacking walnuts, in California, by the station, and was controlled by spraying or dusting with one or two applications of lead arsenate. At the Indiana station, no well-defined second brood was found, and it was necessary to spray all summer to catch them all. At the New Mexico station there were found to be four broods in the State, 75 per cent of the eggs being deposited in July and August, and a spraying schedule has been worked out on this basis.

The best method of controlling crickets, as worked out by the South Dakota station, is plowing and harrowing the fields. Burning piles of old hay and straw also destroys large numbers. The use of poisoned bait has been of little benefit directly, although many crickets are killed by eating poisoned grasshoppers. Studies on cutworm control, at the Nebraska station, indicate that this is probably largely a question of rotation and cultivation.

Investigations on the use of poison bait for the control of grasshoppers, at the Montana station, showed that amyl-acetate could replace lemons in the formula, being much cheaper and easier to use. Its use has resulted in the saving of several thousand dollars in one season. It is conservatively estimated that the saving of the hay crop in one locality as a result of a campaign on grasshopper control carried out by the station was over $100,000, and that the saving throughout the State, due to prompt control measures emanating from the station, must have amounted to several million dollars. A study of the habits of this insect showed that they feed most heavily between 10 a. m. and noon and cease feeding almost entirely by 4 p. m.

Life-history studies of the fish moth, at the Oklahoma station, show that a year or more is required for each brood. For its control, as well as for smaller roaches, the Michigan station finds that sodium fluorid gives very good results. The control of the big American roach has been successful with cake or fermented gruel with molasses, poisoned with lead arsenate.

The Maryland station was successful in controlling the boxwood leaf miner by trapping the adults with sticky materials. A chicken mite, new to the locality, was found by the Indiana station. It had been reported previously only from Maryland and Illinois. The chrysanthemum midge and red spider have been controlled, at the Michigan station, with nicotin sulphate and red pepper.

Studies on the control of the root maggot, at the New Hampshire station, by the use of tobacco dust and lime, showed that the degree of fineness of the dust does not affect the repellent action to any extent. The repellent quality of the tobacco is not impaired by

dilution with lime up to 4 parts of the latter to 1 of tobacco dust. Two applications were more effective than one. The infestation on the untreated plats was 70 per cent, on the treated plats 18 per cent. Cabbage is quite resistant to attacks of the root maggot, but radishes and turnips need protection. Lime was found to be an efficient remedy for controlling bean and cowpea weevils, at the North Carolina station.

The Oregon station has made a detailed study of predacious and parasitic insects, especially enemies of apple aphids and leaf rollers. While climatic conditions do not seem to be very favorable for their action, there is some promise of establishing certain predacious forms that have been introduced from the East.

Almost complete control of the bud moth, in late summer feeding on apples, was obtained at the Pennsylvania station by delayed dormant spraying with arsenicals, followed by the complete schedule of sprays.

The New York Cornell station finds that the hawthorns are native hosts for at least seven serious insect pests of apples. Attempts to control the apple maggot, by the use of sweetened arsenicals, at the New Hampshire station, were not successful. The Colorado station secured good control of the apple leaf roller by spraying with miscible oils before the eggs hatch in the spring. The New Jersey station reports that the use of paradichlorobenzol has been very successful in destroying the peach borer. Two dusting applications of nicotin with sulphur and one of sulphur and lime gave 94 per cent control of the terrapin scale on peach trees, while one application gave only 75 per cent control at the Maryland station. At the New York State station, the pear sinuate borer was controlled by spraying with lead arsenate. Experiments have indicated the superiority of miscible oils and nicotin over other spraying mixtures for combating the pear thrips. Studies of the spinning sawfly of the plum, at the South Dakota station, showed that 50 per cent are destroyed by parasites and ants. Spraying with one-half pound of dry or 1 pound of paste lead arsenate, in 50 gallons of water, when the larvæ are quite small, gave good control.

In the entomological work at the Florida station, it was found that thrips cause the destruction of a great deal of the bloom of citrus trees, and in cases of heavy infestation and light bloom, spraying increased the amount of fruit about 300 per cent. One spraying was found to diminish the amount of thrips-scarred fruit about 50 per cent. The camphor thrips was found to be a native insect, occurring on a species of wild bay tree. It may be controlled on the camphor by spraying or by cutting the trees close to the ground each year, but it is a question if either of these methods is commercially practicable. Nematodes have been successfully controlled by applying

sodium cyanid at the rate of 600 pounds per acre, wetting the soil to a depth of 18 inches and following immediately with an application of ammonium sulphate. The cost is about $200 per acre. Sulphur was found to be of no value as a remedy, and summer fallowing for this purpose is not advisable, as it impoverishes the soil.

The Mississippi station notes the possibility of the hickory bark beetle becoming a serious pest of the pecan. Adults have been found feeding on twigs of the latter.

The cranberry blossom worm was readily controlled, at the New Jersey station, by covering the bogs with water for 24 hours about June 2. The Arkansas station finds the control of the strawberry weevil to lie partly in cultural methods. Dusting also gave good results. Among the varieties Aroma appears to be practically immune.

The striped cucumber beetle was successfully controlled, at the Ohio station, by dusting with a mixture of 20 parts of land plaster with 1 part of lead arsenate, by weight, when the plants first came up, followed by three or four applications about a week apart. At the Massachusetts station, baited flytraps caught a large number of flies of the onion maggot, which was found to be an easier and less expensive method of controlling this pest than spraying.

The Alabama station reports that dusting cotton with calcium arsenate was quite efficient in controlling the boll weevil if properly done. It should begin about one month after blooming and be repeated every five or six days for several applications. The net profits from this practice were found to be about $20 per acre. At the Mississippi station the use of this remedy gave an increase in the crop of 155 to 236 pounds per acre.

Investigations on the potato leaf hopper have been carried on at a number of the stations. At the Michigan station it was controlled with Bordeaux mixed with lead arsenate and nicotin, and the Wisconsin station reports similar success with Bordeaux. At the Pennsylvania station complete control was secured both with Bordeaux and nicotin and by heavy applications of lime, but the latter decreased the yield. At the Iowa station it was found living and breeding on curly dock, indicating that this is an important host plant. All of the nymphal stages were found to be capable of producing symptoms of tip burn, but the older the nymphs, the greater the injury. The adult hopper is not as effective in producing the disease as the nymphal stages. Two sprayings with Bordeaux, 4:4:50, with an addition of 9 ounces of nicotin sulphate to each 50 gallons, gave good protection.

The California station has made extensive studies on the connection of leaf hoppers with sugar-beet blight. The insects leave the beet fields in the fall, going to the foothills, where they winter over, the

spring brood hatching on wild hosts, of which 38 species have been found, and migrate back in the spring, carrying the disease. Some stragglers, however, may remain in the valleys over winter. The migrating dates have been determined in different sections of the State. Beets planted early, in December or January, generally escape infection. A noninfected insect may become infected by a plant before the disease shows on the latter. The insect does not appear to be simply a mechanical carrier, there being evidence that there is an incubation period in the body of the insect. Pulverized clay containing 10 per cent of a commercial preparation of nicotin sulphate at the rate of 100 to 150 pounds per acre will kill the insect if the preparation used is of full strength. The loss is very serious, whole crops being often destroyed, the maximum injury occurring every five or six years. Studies on the sugar-beet root louse, at the Montana station, have demonstrated its effective control by irrigation practices which have been worked out by the station. Growers are adopting it, the saving being estimated at many millions of dollars.

The Alabama station finds the cowpea louse to be the same as the cotton and melon louse and that the locust and spindle tree are also hosts. It changes its color and size on different hosts and has thus been given different names by various observers. A number of host plants of the velvet-bean caterpillar have been found by the Florida station, including kudzu, the horse bean, and a species of carica. Frost kills it out each winter, but it migrates from the South, and it is possible to predict caterpillar years from the occurrence of frost and cold periods in the southern part of the State.

Studies on the aphis which occurs on sunflowers (*A. helianthi*), at the Colorado station, show that it may have a number of plants for a winter host, among them the dogwood, yucca, and milkweed, and it has been described as a distinct species from each of these plants.

The Kentucky station finds that both the northern and southern tobacco worm have at least two broods annually, with possibly a late third, but both pass through changes in the field together and can therefore be treated alike. It is recommended that the crop be sprayed each year about the middle of June, making some allowance for the forwardness of the season, and again on August 1, followed by fall plowing to destroy the hibernating pupæ. The tobacco flea beetle was effectively controlled, at the North Carolina station, by dipping the plants in calcium arsenate at the time of transplanting.

The Ohio station reports that with complete weather observations, especially in the level prairie regions, the best wheat-planting dates to escape the Hessian fly can be accurately determined. Seven days after the maximum emergence gives the best results, the date, which varies with conditions, being determined each year. The South

Dakota station finds three broods of the wheat-stem maggot, one in June, one in July, and the third in September or October, the first being the most injurious. A number of host plants have been found, including many cereals and wild grasses. Poison bait and trap crops have given fairly good results in its control.

The Mississippi station has made extensive studies on the crawfish. Its eradication with carbon bisulphid has been successful, killing 98 per cent if applied at the right time, and one repetition clearing up a field, but is rather expensive. It costs $7 to $8 an acre to treat by hand, and a strip 30 yards wide is necessary to prevent migrants from outside lands where they are abundant. A young crop of corn or cotton may be entirely destroyed by them in one night if rains come.

FOODS AND NUTRITION.

Much work has been done by a number of the stations on the subject of the vitamins. The Connecticut State station has made important contributions on the distribution of water-soluble vitamins. These studies, with those of other investigators, place the dietary importance of green vegetables in an entirely new light and emphasize their use as supplements to products rich in proteins, fats, and carbohydrates, but in many cases comparatively poor in vitamins. Fruits and vegetables are found to owe their well-recognized usefulness largely to their rich vitamin content. Potatoes were not found to be especially rich in vitamin, and no difference was found in this respect between old and new potatoes or between the peel and inside of the tuber. Tomatoes were found to be rich in both water-soluble and fat-soluble vitamins, as well as the antiscorbutic vitamin, and these showed a potency superior to other vegetables tested. Beets were less potent in this respect than most other vegetables.

Alfalfa, clover, spinach, and carrots were found to be rich in fat-soluble vitamin, which was about as efficacious as that in butterfat. The juice of oranges, lemons, and grapefruit is about as rich as cows' milk in water-soluble vitamin, while pears, apples, and other fruits contain only small quantities of it. Fat-soluble vitamin is either low or absent in fruits. It has been demonstrated that milk is one of the best carriers of this form. The milk of cows on grass was not found to be particularly rich in water-soluble vitamin, being about the same as human milk in this respect. The fat-soluble vitamin in butterfat is quite stable and was found to be effective after heating to 120° C. for 16 hours. In a comparison of grains fed to rats, including wheat, oats, barley, and rye, barley gave the best results. Oats were not eaten readily. Rye produced a good growth at first, but its continued use was followed by a high mortality. Wheat was found to be adequate for producing growth.

Water-soluble vitamin is found to be essential under all conditions, while fat-soluble vitamin is not so continuously necessary. A method has been devised for concentrating the water-soluble vitamin of yeast to about 6 per cent of the extract. At the Iowa station, xerophthalmia, a disease caused only by deficiency in fat-soluble vitamin, has been produced in rabbits under conditions that suggest that herbivora require more of this element than omnivora, as swine or rats, swine showing considerable tolerance for such a deficiency.

Experiments at the Wisconsin station show that the concentration of the antiscorbutic vitamin in milk is dependent upon the diet, summer-pasture milk being much richer in this element than dry-feed milk, involving the use of corn silage or mangels. Extensive studies have shown that fat-soluble vitamins are constantly associated with the yellow pigments of plants, but in animal tissues the association is not so marked.

The Arkansas station finds the Georgia velvet bean to be very rich in fat-soluble vitamin, but the seed is found to be low in salts and the hulls to have no supplementary value. The leaf is the most nutritious part of the plant, in that it furnishes the necessary salts and is fairly rich in water-soluble vitamin.

Wisconsin station experiments on nutrients from single plant sources showed that a ration made from the oat plant, both grain and straw, was inadequate for the nutrition of breeding cows, the offspring being born prematurely and either very weak or dead. The addition of fat-soluble vitamin or of casein did not improve the ration for reproduction. When calcium salts only were added, however, a marked improvement was noted. The data secured indicate that where all other nutritive factors are satisfied, the ration of a dry breeding cow should contain at least 0.45 per cent of calcium oxid. Marsh and timothy hay, where they contained as much as 1 per cent of calcium oxid, were found to be very efficient roughages for reproducing cows. Alfalfa hay was found to be particularly efficient in maintaining a positive nitrogen balance in dairy cows.

At the North Dakota station, calves and yearlings, fed on high and low protein rations of equal net energy, showed no distinct differences attributable to the rations. Similar studies with calves at the Virginia station indicated that the protein was less efficiently digested in a low-protein diet, showing that it is more economical to have a liberal amount of protein in the ration. Studies on the protein and energy requirements for milk production showed that 1.87 pounds of digestible protein was required to produce 1 pound of protein in milk, or 0.053 pound of protein to produce 1 pound of milk. The amount of energy required in the food to produce one therm in the milk was 1.05 therm, or 0.315 to produce 1 pound of

milk. The experiments indicate that when a cow begins her lactation period with a lack of digestible protein and excess of energy, her digestion coefficients fall, she loses flesh rapidly, and her milk flow continues to decrease, at first rapidly and later more slowly.

A study of the protein compounds of corn, at the Illinois station, showed the deficiency of corn for the growth of young animals to be due to two amino acids and too low protein concentration. Vegetable proteins proved to be as valuable for maintenance as milk proteins, but not for growth. A study of the best time to cut corn to get the greatest amount of nutrients showed a gradual increase up to the ordinary time of cutting, at which time there is more dry matter, fat, and carbohydrates than before or after, there being about 10 per cent less a week earlier or later. It was found that corn stover silage would maintain beef cattle at a cost of 7 cents per head per day when fed with 1 pound of corn, but was suitable for maintenance only, not for fattening or milk production.

The Ohio station finds that the potential acidity and alkalinity of the supplement in a ration affects the alkali reserve of the blood. Calcium carbonate increases this, while the bicarbonate, a potential acid, decreases it. A study of the comparative value of calcium compounds for swine indicated that the relative solubility was of little importance, the principal factors being mechanical condition and palatability. An animal can take more calcium phosphate than carbonate. Steamed bone with 10 per cent tankage was a good mineral supplement for swine and steamed bone with one-fourth salt for cattle. The Iowa station finds that swine are not only tolerant to acid rations, but rations made strongly alkaline with sodium hydrate and carbonate were quite efficiently handled.

The Pennsylvania Institute of Animal Nutrition has deduced a simple formula by which the heat production of a resting animal may be computed from the live weight, food consumed, and carbon dioxid produced, and a simple method has been formulated by which the amount of animal heat available as the motive power for ventilation may be approximately computed.

ANIMAL HUSBANDRY.

A study of age as a factor in animal breeding carried on at the Missouri station with cattle indicated that if conditions were good pregnancy seemed to have no bad effect on the growth of heifers bred as young as possible, but it is inhibited somewhat by lactation. The offspring of young heifers, although somewhat smaller at birth, are just as vigorous and capable of maximum development as the offspring of mature cows, but growth is a little slower, and with hogs it required about two weeks longer for the offspring of very young mothers to reach 250 pounds.

Experiments have been completed at the Missouri station on the growth that may be expected of normal beef animals when fed all they will eat, a ration for growth only, and one representing poor farm conditions, from birth up to 4 years of age. The first group weighed 2,000 pounds at this age, the second 1,000 pounds, and the third 1,200 pounds. No difference was noted in the height, but in length there was a decrease of 10 to 12 per cent and in the girth at the chest of 20 to 25 per cent with the lower rations as compared with the higher. The effect of plane of nutrition on subsequent development showed that a starved animal put on a full ration made a more rapid gain at a cheaper rate than a full-fed one, but never caught up in total weight.

Very favorable results have been obtained at the Nebraska station in the raising of dairy steers for beef. The percentage of high-priced cuts did not vary essentially and the quality of the meat was equal to that of medium fat steers of the beef breeds.

The Texas station reports that $1\frac{2}{3}$ tons of silage are equivalent to 1 ton of cottonseed hulls for fattening steers. Peanut meal proved of equal value to cottonseed meal and produced no bad effect on the carcass, but apparently was not as palatable. Tests of the value of silage for feeding breeding heifers at the Wyoming station showed a reduction in cost and an increase in rate of gain by its use. In a comparison of corn and sunflower silage fed to beef heifers at the Oregon station palatability was an important factor in the amount eaten, and the gain for the first year's experiment was larger for the corn silage. The same held true with dairy heifers. In feeding experiments at the Oklahoma station sunflowers have proved so satisfactory that they are now being grown quite extensively for silage. Successful results were obtained at the South Dakota station with silage made from millet, it being eagerly eaten by steers and fair gains made.

In steer-feeding tests at the Wyoming station, decreasing the amount of alfalfa hay increased the cost of gain. Pea straw proved very satisfactory at the Washington station for both cattle and sheep. The digestive coefficient of both carbohydrates and proteins of this material is very high. At the Pennsylvania station the use of molasses as a source of carbohydrate for fattening cattle proved economical and beneficial. Cattle receiving 4.6 pounds of molasses in place of an equal amount of corn made 0.25 pound heavier daily gain and outsold the other cattle 50 cents per 100 pounds on the market.

At the Utah station, a liberal amount of grain supplement (corn and mill run) fed with alfalfa hay to steers was found to be economical and profitable. One lot on alfalfa hay alone gained 171 pounds in 90 days; another lot, with the addition of 12 pounds of grain,

gained 235 pounds. Experiments as to the extent to which cotton-seed meal may be fed to live stock, at the North Carolina station, showed that in fattening cattle, up to 10½ pounds per head daily could be fed without bad effects, if the animals got a succulent roughage like silage, but on dry feed there was some injury. With sheep, feeding up to two-thirds pound a day caused no difficulty, except that the ewes fed this amount lambed earlier than normal, although the lambs were healthy.

The North Dakota station found it profitable to finish up grazing steers on corn before marketing, the average returns being $60 per acre for the corn. The heaviest gains by steers on the range were made in the early part of the season, with corresponding less gains in the summer and fall. Five acres of pasture were found necessary to carry a two-year-old steer. At the New Mexico station, cows that were properly maintained during the winter, by a little feed in addition to that furnished by the range, produced calves that averaged at birth 11 pounds more per head and 73 pounds more at weaning time than calves from cows kept wholly on range. All of the fed cows produced calves the second year, while only 1 in 5 of the range cows produced a calf.

Attempts at the Oklahoma station to secure winter and fall lambing are giving some results, the early lambing character seeming to be imparted by Dorset and Rambouillet crosses. Sheep fed in the open, at the Missouri station, required 6.4 bushels more corn per 100 pounds of gain than a lot fed the same ration in the barn.

In a comparison of sunflower with corn silage, at the Oregon station, while the former did not seem to be as readily eaten at first, later it was eaten with great relish and the gains reported were in favor of the sunflower silage, both in cost and amount of growth. Sunflower silage for lambing ewes, at the Nevada station, gave a heavy increase in the milk supply and better nourished lambs. This is important, because sunflowers will grow where corn is a failure. At the Montana station, sunflower silage was not found equal in feeding value to alfalfa hay, for wintering breeding ewes, although the ewes fed upon it came through the winter in fairly good condition and produced normal lambs. The Missouri station finds that clover hay alone is sufficient to maintain pregnant ewes up to lambing time. From one-fourth to one-half ounce of salt daily for pregnant ewes was found to give good results, at the Iowa station.

At the Missouri station, lambs from a purebred ram brought $7.35 per 100 pounds, while those sired by a scrub ram, at the same age and on the same feed, sold for only $4.50 per 100 pounds. The first lot weighed more at three months than the second lot at four months.

An experiment at the Texas station, comparing gains made by crossbred and purebred lambs, led to the conclusion that when lambs are raised under range conditions, in western Texas, there is no special advantage in crossing mutton rams on fine-wool ewes. The fine-wooled sheep are more hardy, better rustlers, and withstand extreme range of temperature and drought better.

The grain sorghums are extensively grown and are the safest crop in western Texas. A test of their feeding value for lambs showed them to have 93 per cent of the value of corn, whereas the market price averaged 20 per cent higher for corn than for milo. The test showed conclusively that corn shipped into that section could not compete successfully with the grain sorghums for fattening lambs. A profit of $1.25 per head was realized, at the Oklahoma station, on lambs fed on alfalfa silage and shelled kafir. In a comparison of oats and barley with corn for fattening lambs, at the Iowa station, with a complete substitution, the oats had a value as compared with the corn of 77.5 per cent and the barley 91.95 per cent. At the Kansas station, self-feeders were not successful with sheep, as they do not choose a balanced ration. The cost of 100 pounds of gain when hand fed was $13.27 and on the self-feeder $15.82.

Wool studies at the Wyoming station showed the breaking strength of both scoured and unscoured wool decreased and the elasticity increased, with increase of moisture. Wool fibers, exposed to the weather, lost about 30 per cent of their tensile strength by the end of one month and at the end of the second month had deteriorated too much for further testing. Studies on the effect of alkali showed that sulphate of magnesia and sulphate and carbonate of soda did not materially increase the injury of samples of wool exposed to the weather.

Investigations in swine husbandry have been quite extensive. Studies on the effect of feeding cottonseed meal on breeding showed that if the animal is in good condition there were no apparent effects on the spermatozoa until symptoms of poisoning begin to show, when they deteriorate. At the Missouri station, fattening hogs gained 32.6 per cent faster on a ration of corn and tankage and 38.5 per cent on a ration of corn and soy beans than on corn alone. A faster gain of 7.4 per cent was made when self-fed than when hand-fed on the same ration. The saving of grain resulting from the use of pasture crops was from 20 to 50 per cent. Of the forage crops tried, clover gave the highest returns, being 567.7 pounds of pork per acre.

The Iowa station finds that oats are not profitable for fattening hogs, having only from 40 to 65 per cent of the value of corn, but for growing pigs the relative value was 93 per cent that of corn.

Some striking results were obtained in feeding orphan pigs, on the effects of adding feeds carrying vitamins in abundance. Five lots of pigs were fed for 90 days, by the "free-choice" method, on a mixture of shelled corn, meat meal tankage and salt, with a quart of whole milk daily per pig for the first 60 days. The check lot received only this basal ration and were fairly healthy. One lot received, in addition, the juice of one orange per pig per day, mixed with the milk, and gained 24 pounds per pig, or 44 per cent over the check lot, due to the orange juice. Another lot, receiving one egg daily per pig, gained 22.5 pounds or 41 per cent more than the check lot, and a lot receiving 5 ounces of tomato juice gained 25 pounds, or 45 per cent over the check lot and were the smoothest finished.

Studies on the effect of the amount of fiber in the ration for fattening hogs, at the Indiana station, showed that with 5 per cent there was some depreciation in the gains, which became more marked as the fiber increased, 10 per cent showing a decided hindrance to rapid and economic gains. Corn and tankage containing about 2 per cent of fiber gave the most satisfactory gains. Some commercial feeds were found to have as high as 20 per cent of fiber.

Feeding blackstrap molasses to hogs, at the Mississippi station, showed about 1.8 pounds to be equal to a pound of corn. At the Oregon station, cane molasses was fed in comparison with barley, the results showing that it could be fed up to 45 per cent of the ration without injury, and was equal to barley, pound for pound.

Winter wheat, sown in the spring, proved to be good pasture for hogs. A comparison of forage crops for swine at the North Dakota station demonstrated the superiority of alfalfa for this purpose and also that grazing is a necessary practice for economic pork production. At the Oklahoma station, sweet clover gave a better pasture for hogs than alfalfa, very shallow planting giving the best results. Dwarf Essex rape produced the most economical gains and a greater amount of pork per acre than rape with oats or with oats and peas. At the Mississippi station, 5¼ acres of corn and soy beans grown together carried 75 hogs for 31 days, with a daily gain of 1.12 pounds per hog, and produced 495.7 pounds of pork per acre.

In a comparison of self-feeding and hand-feeding, at the Wyoming station, the self-fed group made faster though less economical gains, the indications being that self-feeding is not to be recommended for young breeding stock.

A comparison of tankage and fish meal, at the South Carolina station, proved the latter to be a little more economical and to give good gains. Pound for pound it was superior to tankage.

Some interesting results were obtained at the Kansas station on the value of alfalfa as a supplement to corn and tankage and kafir and tankage. The corn and alfalfa ration did not give as good

results as alfalfa and kafir, due evidently to a deficiency of protein in the corn. White kafir was found to be deficient in fat-soluble vitamin. The common hog ration in the State is alfalfa, corn, and tankage, which seems to account for the poor results often obtained. Kafir and tankage, supplemented with alfalfa meal, is much more nearly adequate than corn and tankage. Excellent results were obtained at the New Mexico station in feeding pinto, tornillo, and mesquite beans, both to sheep and hogs.

In experiments in feeding barley to hogs, at the Oklahoma station, ground barley gave better results than the whole grain. A test of the best method of feeding barley to fattening hogs at the Indiana station showed good results from mixing ground corn and barley in equal parts by weight and properly supplementing with tankage. If fed ground barley and tankage separately, in self-feeders, an excess of tankage was consumed. The Illinois station finds that a supplementary feeding of mineral matter is unnecessary in a well-balanced ration, but if this consists mostly of corn it is necessary.

A number of investigations have been carried on by the southern stations on the subject of soft pork. At the Oklahoma station it was found that cottonseed meal will harden pork better than corn, and that barley may also be used for this. The melting point of fat of hogs fed cottonseed meal was about 1.5° higher than that of other lots. Studies on rabbits showed that in starvation the liquid and softer fats of the body were used up before the harder fats, which suggests a possibility of thus getting rid of the soft fat of peanut-fed hogs before finishing on hardening rations. At the Kansas station, studies on the effect of feed on the composition of the body fat showed that none of the short-chained fatty acids are deposited in the body fat, while the unsaturated fatty acids are so deposited. The body fat produced on a high-protein diet differs from that produced on a low-protein one.

The Texas station finds that while large amounts of rice bran in the feed will produce a pork classed as medium soft, which, however, is white and will not drip, it may be fed to the extent of 50 to 60 per cent with corn chops and tankage and not produce a carcass that will be classed as soft. It does not appear to be as bad in this respect as peanuts. Pigs receiving a ration of 90 per cent rice bran with 10 per cent tankage, as compared with a lot fed with the self-feeder, made smaller daily gains, but at a less cost per 100 pounds of gain.

The Florida station reports a considerable variation in the melting points of the fat from different hogs on the same feed. From the standpoint of the melting point, anything below 33° C. is rated by the packers as soft and oily, from 33° to 38° C. as medium hard, and over 38° C. as firm. A method has been devised of securing samples

of the fat from the live animal, without injury, which promises important results in studying the effect of feeds. The Georgia station finds that ordinarily the outer layer of back fat is softer than the inner layer, but that this appears to be reversed by heavy peanut feeding.

At the Mississippi station, of hogs grazed on peanuts alone and then finished on corn and tankage in the self-feeder for 4, 8, and 12 weeks, the 12-weeks lot barely got above the soft grade.

As the result of extensive poultry investigations, the California station reports that with 1,000 birds to the acre, three times the profit is obtained than the same acre would yield in alfalfa. Studies at the North Carolina station, on the length of time required for food to pass the digestive canal, showed that this varies largely with the age, activity, and other factors. In nonlaying hens it required about 8 hours and in laying hens a little over 3 hours. With sitting hens the time required was about 14 hours and with young growing chicks about 4 hours.

The New York Cornell station finds it possible, with considerable accuracy, to judge the value of hens for laying by body characteristics, thus enabling the elimination of unprofitable birds while they are young, saving the expense of trap nesting and of keeping undesirable birds until their value is learned, and avoiding the danger of using eggs for hatching from low-producing birds. Continued inbreeding, at the Wisconsin station, has reduced the hatchability of eggs to zero in 5 or 6 years.

At the Massachusetts station, successful results have been obtained in combining a nonbroody and a high egg-laying strain. The results obtained at the Maryland station in culling methods have received wide application.

In investigations on the deficiencies of feed fed to hens as affecting the vitality of chicks, at the Kansas station, it was found that a low-protein diet gave a small number of eggs with a loss in weight. A low fat-soluble vitamin ration gave a fairly good egg production, but the hatchability was very poor and the mortality very high. With a low water-soluble vitamin diet good egg production and hatchability were secured, with chicks normal in size and vigor, but with a loss in weight and a high mortality. It was found possible to vary the vitamin content of the egg by varying this element in the food, especially the fat-soluble vitamin. There was evidently something in green alfalfa and milk that was highly beneficial. It was also found that with chickens fed a ration deficient in fat-soluble vitamin the eyes were affected first, which is believed to account for the prevalence of roup, as birds fed with a ration containing suffi-

cient of this element could not be infected with the disease. At the Minnesota station, a vitamin-free diet of polished rice fed to cockerels caused atrophy of the testes, which did not occur, however, if a small amount of green alfalfa was fed with the rice.

Feeding experiments at the New Jersey station showed conclusively the importance of finishing pullets by heavy feeding of grain in the late fall and early winter, in order that they may come into production in a heavy, natural, well-fleshed condition, thus being able to carry through later in the following summer and to stand up under the strain of heavy and continuous egg production. In an experiment at the Kansas station on feeding single grains to chicks, all died within 5 weeks, corn alone giving the earliest mortality and kafir showing the most gains.

At the Nebraska station a ration of wheat, casein, butterfat, and ash, fed to chicks, did not result in normal growth, which was, however, secured by the addition of 5 per cent of wheat greens. Leg weakness in chicks was found to be due to a lack of suitable roughage in the ration, at the Wisconsin station. With concentrated rations alone this was serious, but 10 per cent of roughage was sufficient to grow normal chicks, and paper was found to answer this purpose. Exercise, green feed, or even orange juice did not prevent the occurrence of leg weakness if the bird was overfed a concentrated ration.

At the New Mexico station, hens fed on alfalfa meal returned 51 per cent of the nutrients fed, in the eggs, but with meat scrap, alfalfa, and bran only 28 per cent was returned. At the Oklahoma station, a ration containing from 20 to 25 per cent of beef scrap gave the best results. Meat scrap, added to a basal ration, with Plymouth Rock pullets, at the Indiana station, increased the average egg production from 50 eggs per bird per year to 100 eggs, and decreased the cost per dozen eggs 20 cents. The Iowa station found it profitable to feed from 15 to 25 per cent, by weight, of tankage in the mash, which, in the summer months, with free range, can be reduced to 10 per cent.

At the Kentucky station, it was found that laying hens, whose supply of lime was limited to that in the food, suffer a general depletion of magnesia, phosphorus, and lime from the bones and carcass with continued egg laying. The addition of limestone or oyster shells to the ration increased the production of eggs nearly 70 per cent.

The Utah station has three hens that have gone without molting for two years and have laid over 200 eggs apiece per year, and attempts are being made to establish this character by breeding.

The Maryland station has made a study on the effect of age on the hatchability of eggs and finds that this begins to decline after seven days. Chicks hatched from eggs kept longer than this are less vigorous. It is found, at the West Virginia station, that the vigor of

the embryo, during incubation, can be measured by the carbon dioxid given off. More than half of this is given off during the last quarter of the incubation period, and during that time ventilation should not be restricted.

The fertility and hatchability of eggs in lighted houses was found at the Utah station to be higher than of those from unlighted. Early morning lighting only seems to be most profitable. Artificial illumination of henhouses was originated at the California station. Observation has shown that it gives a change in season of production, but does not increase the yearly output, except with poor layers. The best results were obtained in lighting from October 30 to March 1, from 4.30 a. m. to daylight. The New Jersey station, on the other hand, finds that lighting for an evening lunch period, between 8 and 9 p. m. gave as good results as when morning or evening lights were used.

DAIRY HUSBANDRY.

At the Maine station, the effect of every Guernsey bull, where records of two or more of his progeny were available, has been worked out, giving a comprehensive and scientific measure of the true breeding worth and value of the various blood lines of this breed, which is one of the most practical results of the station's work for the farmer, dairyman, and breeder.

In a comparison of early and late fall calving, at the Mississippi station, late calving, October 15 to December 31, gave 16 to 17 per cent more milk and fat. Fall calving gave a larger yield of milk and fat than spring calving.

At the Iowa station, the substitution of cottonseed meal for corn caused a temporary increase of 12 per cent in the fat content of the milk. Soy beans proved to be equal to linseed meal, pound for pound, for milk production. Dairy cows were found to have a greater maintenance requirement when in high than when in low condition. The water requirements varied little on account of conditions, but a low condition was accompanied by an abundant salt consumption.

A study of the soiling system under Nebraska conditions, by the station, showed that soiling crops correlate well with specialized dairying, in the distribution of labor throughout the day, and that cows will maintain a more constant yield throughout the summer on a good ration of soiling crops than on any other feeds, thus decreasing the necessity for a heavy grain ration. The labor required, however, is somewhat greater. Dairy calves on the self-feeder consumed a much greater amount of grain than those fed by hand and made a more rapid growth, with a material saving of labor and no ill effects.

The Indiana station devised a successful milk substitute for young calves, consisting of a mixture of 12 parts of beef blood, with one part each of corn meal and oil meal.

An analysis of milk records, at the Maine station, shows that the parts of the conformation having a distinctly significant relation to milk production are the milk veins, size and condition of the udder, shape and size of barrel, and the general appearance of the cow; but a seven-day test is superior to conformation as a guide to milk production. Extensive studies of herd records showed that the highest production was in February and March, the lowest being from July to September.

At the Missouri station, dairy cows showed a decided increase in fat in the milk when the rations were diminished, falling off somewhat after a few days, but when returned to full feed the percentage went down rapidly and remained below normal. The amount of milk varied almost directly with the amount of feed.

It was found at the Texas station that with cows fed on cottonseed meal and silage, each pound of butterfat produced cost the station 48 cents. At the Minnesota station, the vitamins in the diet were found to bear a direct relation to the vitamin content of the milk. Spring milk is superior to winter milk in vitamins. With a deficiency of these in the diet they decline very gradually in the milk, but increase rapidly with an improved ration. The vitamin content of butter was found to undergo a seasonal change, as with milk. The Pennsylvania station finds sunflower silage to have only about three-fourths the value of corn silage for milk production, but 20 tons of the former were secured, compared with 12 tons of the latter, per acre. At the Washington station sunflower silage proved to be 92 per cent as efficient as corn silage for dairy cows and to have about 75 per cent of the feeding value of good alfalfa hay.

A comparative test, at the Montana station, of sunflower silage and alfalfa hay indicated that 1 pound of the latter was equivalent to 2.9 pounds of the silage, the milk and butterfat percentage on both being about equal. Results with this material at the Michigan station showed that the sunflower silage alone was not as satisfactory as corn, but a mixture of the two was better than either one.

In an experiment at the Wisconsin station in feeding hydrolyzed sawdust to dairy cattle, 1 pound of treated white-pine sawdust substituted for 1 pound of barley, when fed not to exceed 25 per cent of the ration, was eaten readily and the flow of milk was maintained. Sawdusts containing a large amount of resin are not suited for feeding purposes.

The feeding of coconut, peanut, and soy-bean oils to milk cows, at the Massachusetts station, caused a marked depression in the soluble acids of the butterfat. Coconut oil caused an increase of 1 per cent in the fat. When coconut meal was fed to the extent of 4 pounds per day at the California station it was found to impart a taste to the milk.

The Illinois station has demonstrated that the greatest source of contamination is the milk pail and other containers. The New York State station finds that the carbon-dioxid content of milk is a reliable test as to whether it has been pasteurized. Under the conditions in which normal unheated milk is handled, from milking to delivery to the consumer, the volume per cent of carbon dioxid seldom drops below 3.5, while heating reduces this to 2.5 per cent or less. Normal milk contains about 15 per cent of carbon dioxid, but in diseased conditions it runs much higher. As a rule about one-third is free, the rest being in combination. At the Indiana station, bitterness in evaporated milk was found to be caused by *Bacillus panis*, which has a thermal death point of 250° F. for 10 minutes.

In the use of milking machines, at the New York State station, the chief difficulty was found to be due to the growth of bacteria in the tubes and pails between milkings.

Studies on the cause of metallic flavors of butter, at the Michigan station, showed that they may be caused by certain bacteria of the *subtilis* group. Certain metals, as arsenic, calcium, zinc, and iron, may cause this flavor, but it is transient, while that caused by bacteria continually increases.

At the California station, preserving butter in 30 per cent brine gave good results, keeping it well for five weeks in summer. The Indiana station finds sandiness in ice cream to be due to the precipitation of milk sugar. From 10 to 12 per cent of milk solids in the fat seems to be the upper limit which can be used without producing this condition.

VETERINARY MEDICINE.

Two distinct strains of *B. botulinus* have been isolated at the Illinois station that will not protect against each other. An antitoxin for this bacillus, which is the most common cause of forage poisoning in horses and of limberneck in fowls, has been perfected at the California station, that, while not especially curative, has a distinctly prophylactic effect.

In contagious-abortion studies, at the Connecticut Storrs station, heifers fed with virulent cultures remained negative, but were easily inoculated through the vagina and urethra. It has been demonstrated that the disease is not transmitted from dam to calf. Disinfection of the sheath of the bull, before and after service, is giving excellent results in its control. In similar experiments at the Missouri station of seven heifers from a nonreacting herd, bred to a negative-reacting bull, two were fed cultures of the bacillus and aborted, the bacilli being recovered from the fetus. Two others received injections of the bacilli under the skin and developed a positive reaction, but carried their calves all right, except that they

were seven or eight days premature; the bacilli were recovered from the placenta and the milk was positive. Two others, in which the bacilli were injected into the vagina, developed a positive reaction, calved prematurely, and the bacilli were found in the udder. Two others, with the bacilli injected into the teats, also calved prematurely. Apparently irrespective of the manner in which the germs get into the body, they get into the uterus and milk. Sows' milk will react before the blood does.

At the Michigan station, *B. abortus* could not be found in the deeper layers of the mucous membrane of the nongravid uterus of animals recently injected with the disease. The Minnesota station finds that blood tests are of little value in indicating whether an animal has aborted or will abort, but they do indicate the amount of herd infection.

The Kentucky station finds that old cultures of the bacillus of equine abortion, isolated in 1912, retained a considerable degree of virulence. Immunization of mares injected intravenously with large numbers (20 billion) of the live organisms was not successful, such an infection being, however, probably heavier than would be encountered under field conditions. Jennets were found to absorb the germ from the intestinal tract into the blood stream when fed live organisms, as shown by the increase of agglutinins in the blood serum. The use of vaccine as a preventative was quite extensively carried out with encouraging results. Treating aborting cows with bacterial vaccine made from strains of the bacillus from aborting animals, followed with subcutaneous injections of a live culture of the same organism, gave encouraging results as a means of combating the disease.

Tests of commercial bacterins for the control of contagious abortion, at the Wyoming station, showed them to be of no value. The Illinois station has demonstrated that the microorganism of contagious abortion of cattle is a factor in this disease in swine. In tests carried on for three years, at the Arkansas station, transmission of bovine infectious abortion to swine by feeding milk from infected cows has not been successful. The Illinois station finds swine abortion to be an infection of the individual fetus rather than of all the embryos, some pigs in the litter being positive to *B. abortus* (Bang), others not. In the Chicago market, only 0.56 per cent gave a positive bovine-abortion reaction.

In an extensive study of a hemorrhagic disease occurring in cattle, at the Nevada station, the causal organism was not found, but a serum was produced that, with treatment, has reduced the mortality from 95 to 44 per cent. Attempts to identify it with hemorrhagic septicemia were not positive, but the indications are that it is infectious.

Studies on tuberculosis, at the California station, showed that it was not possible to produce infection by tubercular-infected dust. Some success has attended attempts to immunize against *B. necrophorus* infection in rabbits, at the Wyoming station, by the use of a vaccine from the serum of the blood of an infected rabbit.

Studies on the transmission of swamp fever in horses, at the Wyoming station, indicate that the nasal secretions, which are often abundant in affected animals, may be a source of infection. It is also transmitted by the bites of at least two species of flies. The blood of one horse was found to be highly virulent 4½ years after it became infected. No satisfactory diagnostic character has as yet been found, and it seems to be impossible to detect certain chronic cases by ordinary means. The Texas station also reports indications that this disease is transmitted largely by the stable fly. At the North Dakota station, all attempts to produce the disease by means of Gastrophilus extracts have been unsuccessful. Studies on this disease, at the Nevada station, showed that severe infections of parasites may give symptoms very closely resembling it. It appears to be induced by a filterable virus and can be produced by inoculation. No specific diagnostic method has been found and no successful treatment discovered. It also reports the probability of its transmission by biting flies. It is confined wholly to the horse family.

Studies on anthrax, at the Louisiana station, have shown an organism to be very commonly present that is very similar to the anthrax bacillus that may lead to a wrong diagnosis. The organisms are motile, while the anthrax organisms are not, and they are nonpathogenic to guinea pigs.

At the Maryland station, it was found that pigs from immune mothers, inoculated with hog cholera, in all cases showed no symptoms until they were weaned, when they all came down with the disease. Studies on the infectiousness of the blood, urine, and feces from hog-cholera infected animals, at the Indiana station, showed that when these materials were fed to healthy animals in no case did the urine or feces cause infection, but feeding the blood produced the disease. It is not believed that the disease is transmitted by flies, but may be by dust. At the Kentucky station it was found that feeding arsenious oxid to hogs, following the injection of cholera virus, prevents infection. Shaking the virus followed by storage at 4° C. increased its virulence. Virus containing 1 per cent phenol maintained its full virulence for 96 days at 4° C. The Louisiana station has made a study of the mixed infections that frequently follow inoculation of swine for hog cholera. This was found to be widespread and evidently due to reduced vitality caused by the inoculation. It develops rapidly and the hogs die in large numbers. The only means of control seems to be proper sanitation.

In a study of hairless pigs, at the North Dakota station, it was found that in many cases thyroid symptoms were entirely lacking. Hairless litters were found to be about 10 per cent smaller than normal ones, and hairlessness appeared to be most common in litters of gilts. In two lots of sows, fed the same feed, one lot being given exercise and the other lot closely confined, the latter produced hairless litters, the same results being obtained when the lots were exchanged. The condition is not inheritable and seems to be worse some seasons than others. The Washington station secured perfect control of the trouble by the use of iodin.

At the Wyoming station, studies on the muscle parasites of sheep indicated that an intermediate host is not necessary, that there is an apparently infective intestinal stage, and that infection results from eating food contaminated with infected feces. While complete control would seem to be impossible, infection can be reduced to a minimum by avoiding restricted grazing and by scattering the flocks in the morning as they start out from the bedding ground. Moist or wet pastures favor infection, and it is therefore advisable to graze the sheep on drier ranges, especially in the forenoon. Heavy infections of the lungworms of sheep were obtained, at the Oklahoma station, when the eggs were fed. They cause atrophy of the lungs and pneumonia often results. Larval worms have been kept alive in soil and on vegetation, in a dried or partially dried condition, for 14 months.

In studies of the fringed and broad tapeworms of sheep, at the Wyoming station, it was found that natural infection is, as a rule, associated with feeding in damp localities. The Connecticut Storrs station finds that the larvæ of stomach worms of sheep will live over in pastures in the State and that the eggs hatch outside of the body of the sheep. There seems to be some curative value to calcium sulphate and tobacco. At the Texas station it is believed that swell head of sheep and goats may be due to eating blossoms of the Sachrista. Affected flocks, removed from locations where this plant occurs, showed no more symptoms. Treatment with 5 grains of calomel, followed in 12 hours with 6 ounces of castor oil, gave good results.

Results of studies at the Maine station show that the alexins or complement bodies of the blood necessary to complete the chain for the binding of the foreign protein that takes places in disease resistance, are lower in the fowl than in most animals. The Nebraska station is led to to the conclusion that fowl cholera is a form of hemorrhagic septicemia. The use of bacterins and vaccines has not proved very efficient for its control.

The Oklahoma station finds that the roundworm of poultry (*Hymenolepis carioca*) may be transmitted by the stable fly, Stomoxys. When roundworm eggs are fed to chicks they do not develop and are passed out, but when then eaten by chickens they

develop. For their control, chenopodium acted harmfully on the chicks, but a mixture of chloroform, male fern, and tobacco was from 50 to 70 per cent effective. Santonin gave a 50 per cent control of ascarids and 25 per cent of tapeworms. Studies on the nematode roundworm at the Kansas station showed that the eggs as passed in the feces are very resistant, developing after 7 days' exposure to summer sun and 15 hours of continuous freezing at a temperature of 11° F. below zero. Studies of the chicken nematode Heterakis, at the Minnesota station, showed that no intermediate host is required and there is no evidence that the larval forms undergo migrations comparable to Ascaris. Tests with various chemicals and heat, for control, have not been very successful. Viable eggs of the nematode were secured from fowls that had been in cold storage over 9 months.

Very successful results have been secured, at the Kansas station, in the production of pure-culture vaccines for the prevention of roup and fowl typhoid. In treating a large number of birds, in infected flocks, less than 1 per cent acquired the disease. The use of an autogenous vaccine, at the New Jersey station, made directly from the virus from scabs of birds infected with chicken pox, gave very positive results in control of the disease.

The Maryland station reports that the remedy for blackleg and gout of poultry rests on proper feeding. Hens were found to show symptoms of gapes 11 days after being fed infected earthworms.

In a study of blackhead of turkeys, at the Rhode Island station, it was found that flagellates occur in domestic poultry as well as in many wild species, corresponding to the occurrence of *B. coli* in the human species, and it is believed that when these organisms become abnormally numerous or active they cause blackhead, the relation being similar to that between *B. coli* and colitis in man.

Experiments on the use of nitrobenzol as a fumigant for the control of external parasites of poultry and other animals, at the Michigan station, indicate that it can not be used with safety on account of its toxic action, although it may be used, with caution, for collecting parasites, by fumigating at low temperatures for short periods, but is dangerous to use under any condition.

The Nevada station has made some investigations on the biting flies of cattle, and finds that *Tabanus phænops* must have a liquid or semiliquid medium for development, and the larvæ will not mature in well-drained land. It may be controlled by this means. It is believed that this species may carry anthrax.

AGROTECHNY.

Studies by the Louisiana station on the clarification of cane juice show that this rests mainly on adsorption and that it may be accomplished without the use of chemicals. By the use of certain adsorb-

ents, followed by filtration, the same quantity of first sugar of greatly superior quality can be made, the first molasses being very light in color, the recovery of high-grade sugar made directly from cane is increased, and a final molasses with an enhanced value is produced.

The station has also studied the cause of the darkening of cane juice. If the juice was not left alkaline after clarification there was no discoloration as a rule, except in the presence of tannin, which gives a dark-colored sirup, whether iron is present or not, although the presence of the latter gives a darker color.

Excellent results were obtained by the use of decolorizing carbons made from sawdust impregnated with magnesium or ammonium chlorid. The practicability of making a clear, white juice was demonstrated, from which sugar can be crystallized in a condition that needs no further refining, by filtering the raw juice through kieselguhr and treating with 1 per cent of its weight of a decolorizing material. A study of the cause of the deterioration of stored sugar, mainly by inversion, showed the chief cause of this to be molds, the remedy being proper drying under sanitary conditions.

AGRICULTURAL ENGINEERING.

The Utah station finds that four 6-inch irrigations on sugar beets gave a yield of 15.23 tons per acre, and four of 3 inches each gave 10.53 tons. With potatoes, 14 inches gave 165 bushels, 10 inches 125 bushels, 6 inches 113 bushels, and no irrigation 49 bushels. The potassium carried to an acre of soil by 2 acre-feet of water, averaged for all streams 33.4 pounds, phosphorus varied from a trace to 30 pounds, and nitrogen averaged 22.8 pounds.

Experiments at the New Mexico station showed that excellent yields of alfalfa could be produced on the mesa lands when sufficient water is used. The data show that cultivation of the soil after irrigation has no effect on the conservation of moisture on this type of soil. With an average annual application of 55 inches on cropped plats water did not penetrate below the reach of the roots of plants. At the Nebraska station, in a study of the cost of irrigation, 1 gallon of fuel furnished power for pumping 13,272 gallons of water from a depth of nearly 40 feet, the cost being 40 cents per acre-inch of water pumped.

In tests made at the Indiana station, angle or straight bar cleats on tractor wheels gave the poorest results, spike forms being best, causing least disturbance of the soil. Tests of the draft of plows at varying speeds, at the Iowa station, showed that there is an increase in draft of from 16 to 25 per cent as the plow speed is increased from 2 to 4 miles per hour. Limestone spreaders with the revolving finger type of distributor gave the most uniform distribution.

At the Wisconsin station, nitro-starch was found well suited for land clearing, being cheaper than dynamite and resisting freezing, but was not adapted to ditch work.

INSULAR EXPERIMENT STATIONS.

The Office of Experiment Stations continued to exercise general supervision over the experiment stations in the insular possessions, which derive their support from direct Federal appropriation to the Department of Agriculture. These stations are located in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands. The relations of the office with them are in immediate charge of W. H. Evans. Separate reports are made upon their operations.

VISITATION OF THE STATIONS.

The examination of the work and expenditures of the stations was carried on as in the past, each continental station receiving Federal funds being visited by a representative of the office during the year. This examination was participated in by five members of the office force—the Chief (E. W. Allen), W. H. Evans, W. H. Beal, E. R. Flint, and J. I. Schulte.

In addition to this personal examination on the ground, the office maintains close relations with the stations through correspondence, passes upon and approves the projects conducted under the Adams fund, and at the close of the year examines the financial reports of the stations before they are formally approved.

STATISTICS OF THE STATIONS.

For the fiscal year ended June 30, 1920, the total income of the experiment stations was $7,631,254.34, comprising $1,440,000 Federal funds derived under the Hatch and Adams Acts, $210,000 Federal appropriations for the insular stations, $3,594,441.80 State support, $415,610.48 income from fees, $1,223,529.20 returns from the sale of products, $125,916.36 income from miscellaneous sources, and $621,756.50 carried over as balances from the previous year.

The estimated value of additions to the equipment of the stations during the year was as follows:

Buildings	$396,300.70
Library	21,033.34
Apparatus	42,240.46
Farm implements	104,769.72
Live stock	190,059.35
Miscellaneous	497,082.60
Total	1,251,486.17

In the work of administration and inquiry the stations employed 1,968 persons, of which 1,137 were also members of the teaching staff of the colleges and 436 assisted in the various lines of extension work.

The statistics of the stations by States are given in detail in the tables following.

TABLE 1.—*General statistics, 1919–20.*

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.	Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in extension work.	Publications during fiscal year 1919–20.		Number of names on mailing list.
								Number.	Pages.	
Alabama (College)	Auburn	J. F. Duggar	Feb. —, 1883	Feb. 24, 1888	20	15	11	8	81	25,000
Alabama (Canebrake)	Uniontown	J. M. Burgess	Jan. 1, 1886	Apr. 1, 1888						
Alabama	Tuskegee Institute	G. W. Carver	Feb. 15, 1897		10	9				
Alaska	Sitka	C. C. Georgeson			9			2	194	4,232
Arizona	Tucson	D. W. Working		—— —, 1889	25	20	7	5	158	11,000
Arkansas	Fayetteville	Bradford Knapp		—— —, 1887	21	20	1	6	90	10,651
California	Berkeley	H. J. Webber	—— —, 1875	Mar. —, 1888	120	97	85	26	836	38,768
Colorado	Fort Collins	C. P. Gillette		Feb. 29, 1888	42	29		4	122	4,700
Connecticut (State)	New Haven	E. H. Jenkins	Oct. 1, 1875	May 18, 1887	19	1		8	684	9,500
Connecticut (Storrs)	Storrs	do		May 18, 1887	12	5	6	5	109	7,000
Delaware	Newark	C. A. McCue		Feb. 21, 1888	14	4	3	3	122	7,000
Florida	Gainesville	P. H. Rolfs		—— —, 1888	11	4	2	13	145	18,000
Georgia	Experiment	H. P. Stuckey	Feb. 18, 1888	July 1, 1889	5			52	156	11,000
Guam	Guam	C. W. Edwards			5			1		2,983
Hawaii	Honolulu	J. M. Westgate			9		2	2	60	2,744
Idaho	Moscow	E. J. Iddings		Feb. 26, 1892	38	25	10	34	114	12,248
Illinois	Urbana	Eugene Davenport		Mar. 21, 1888	79	58	50	17	446	42,000
Indiana	Lafayette	G. I. Christie	—— —, 1885	Jan. —, 1888	61	24	3	26	1,005	37,498
Iowa	Ames	C. F. Curtiss		Feb. 17, 1888	71	17		25	576	36,000
Kansas	Manhattan	F. D. Farrell		Feb. 8, 1888	77	51		16	377	11,500
Kentucky	Lexington	T. P. Cooper	Sept. —, 1885	Apr. —, 1888	54	22	6	8	493	20,000
Louisiana (Sugar)	New Orleans		Sept. —, 1885							
Louisiana (State)	Baton Rouge	W. H. Dalrymple	Apr. —, 1886		23	5	7	6	286	8,578
Louisiana (North)	Calhoun		May —, 1887							
Maine	Orono	C. D. Woods	Mar. —, 1885	Oct. 1, 1887	17			14	432	20,000
Maryland	College Park	H. J. Patterson	—— —, 1888	Apr. —, 1888	31	13		10	199	20,000
Massachusetts	Amherst	F. W. Morse [1]	[2]—— —, 1882	Mar. 2, 1888	46	20		22	596	26,500
Michigan	East Lansing	R. S. Shaw		Feb. 26, 1888	64	40		20	1,341	45,000
Minnesota	St. Paul (University farm)	R. W. Thatcher	Mar. 7, 1885	—— —, 1888	85	65	5	21	902	11,000
Mississippi	Agricultural College	J. R. Ficks		Jan. 27, 1888	31	14				13,000
Missouri (College)	Columbia	F. B. Mumford		Jan. —, 1818	47	45		24	610	14,576
Missouri (Fruit)	Mountain Grove	F. W. Faurot	Feb. 1, 1900		5					
Montana	Bozeman	F. B. Linfield		July 1, 1893	29	17		15	328	11,425
Nebraska	Lincoln	E. A. Burnett	Dec. 16, 1884	June 13, 1887	37	32	1	9	191	18,400
Nevada	Reno	S. B. Doten		Dec. —, 1887	9	3	1	4	126	6,000
New Hampshire	Durham	J. C. Kendall		—— —, 1886	20	18	15	10	140	17,000
New Jersey (State)	New Brunswick	J. G. Lipman	Mar. 10, 1880		31	20	28	77	1,341	14,650
New Jersey (College)	do	do		Apr. 26, 1888	16					

New Mexico	Agricultural College	Fabian Garcia	.....	Dec. 14, 1889	16	12	9	81	249	10,000
New York (State)	Geneva	W. H. Jordan	Mar. —, 1882	.....	38	.....	.....	28	722	42,937
New York (Cornell)	Ithaca	A. R. Mann	—— —, 1879	Apr. —, 1888	59	55	11	15	1,501	2,146
North Carolina (College)	West Raleigh	B. W. Kilgore	Mar. 12, 1877	Mar. 7, 1887	46	13	.....	3	151	9,000
North Dakota	Agricultural College	P. F. Trowbridge	.....	Mar. —, 1890	34	18	6	4	234	10,000
Ohio	Wooster	C. E. Thorne	Apr. 25, 1882	Apr. 2, 1888	52	.....	5	83	1,825	66,560
Oklahoma	Stillwater	H. G. Knight	.....	Dec. 25, 1890	21	17	.....	10	156	6,054
Oregon	Corvallis	J. T. Jardine	.....	July —, 1888	56	38	12	67	522	1,049
Pennsylvania	State College	R. L. Watts	.....	June 30, 1887	70	70	70	12	262	40,000
Pennsylvania (Nutrition)	....do	H. P. Armsby	—— —, 1907	.....	7	.....	.....	.....	.....	500
Porto Rico	Mayaguez	D. W. May	.....	.....	9	.....	1	3	56	2,775
Rhode Island	Kingston	B. L. Hartwell	.....	July 30, 1888	12	2	.....	12	186	1,775
South Carolina	Clemson College	H. W. Barre	.....	Jan. —, 1888	23	12	8	4	158	4,500
South Dakota	Brookings	J. W. Wilson	.....	Mar. 13, 1887	17	16	.....	6	152	22,000
Tennessee	Knoxville	H. A. Morgan	June 8, 1882	Aug. 4, 1887	16	5	.....	2	179	12,000
Texas	College Station	B. Youngblood	.....	Apr. 3, 1889	46	2	.....	38	1,975	48,648
Utah	Logan	F. S. Harris	.....	—— —, 1890	36	27	12	10	293	9,000
Vermont	Burlington	J. L. Hills	Nov. 24, 1886	Feb. 28, 1888	12	8	1	3	132	2,000
Virginia	Blacksburg	A. W. Drinkard, jr	—— —, 1888	—— —, 1891	24	12	1	3	44	13,000
Virginia (Truck)	Norfolk	T. C. Johnson	.....	.....	6	.....	.....	2	32	6,500
Virgin Islands	St. Croix	L. Smith	.....	.....	2	.....	.....	.....	.....	.....
Washington	Pullman	E. C. Johnson	.....	—— —, 1891	42	25	.....	5	117	10,508
West Virginia	Morgantown	J. L. Coulter	.....	June 11, 1888	31	22	7	11	76	25,000
Wisconsin	Madison	H. L. Russell	—— —, 1883	—— —, 1887	87	78	49	25	704	44,028
Wyoming	Laramie	A. D. Faville	.....	Mar. 1, 1891	13	12	1	7	289	6,000
Total	.....	.....	.....	.....	1,968	1,137	436	927	22,275	933,933

[1] Acting director.
[2] In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch station at the same place.

TABLE 2.—*Revenue and*

Station.	Federal.		State.	Balances from previous year.[1]	Fees.	Sales.	Miscellaneous.
	Hatch fund.	Adams fund.					
Alabama (College)	$15,000	$15,000	$27,000.00	$4,535.69	$1,151.02		
Alaska [2]							$75,000.00
Arizona	15,000	15,000	73,171.14	590.29		$25,377.16	
Arkansas	15,000	15,000	18,896.00			7,500.00	
California [3]	15,000	15,000	149,085.40		4,315.96	79,956.51	13,293.39
Colorado	15,000	15,000	91,440.46	43,421.56			
Connecticut (State)	7,500	7,500	35,000.00	9.76	10,019.33		15,100.70
Connecticut (Storrs)	7,500	7,500	12,625.00	4,034.49			14,316.61
Delaware	15,000	15,000	10,000.00			24,306.91	
Florida	15,000	15,000	8,736.99	4,173.47		5,822.39	
Georgia	15,000	15,000	8,748.92	2,531.20		13,509.37	
Guam [2]							20,000.00
Hawaii [2]							50,000.00
Idaho	15,000	15,000	27,149.98	971.96		2,691.18	
Illinois	15,000	15,000	195,500.00	25,350.63		73,503.09	
Indiana	15,000	15,000	91,000.00	106,750.53	141,737.82	137,247.65	
Iowa	15,000	15,000	222,750.00	9,012.91		53,717.42	
Kansas	15,000	15,000	93,800.00	18,338.74		60,179.39	
Kentucky	15,000	15,000	50,000.00	61,224.36	123,576.03	35,117.09	4,101.33
Louisiana	15,000	15,000	26,541.70			6,441.68	11,673.11
Maine	15,000	15,000	15,000.00			18,001.44	18,753.88
Maryland	15,000	15,000	32,167.47			22,030.37	
Massachusetts	15,000	15,000	55,875.80	16,834.83	10,925.79	5,530.79	2,177.79
Michigan	15,000	15,000	104,970.14		23,468.82	8,572.44	2,689.33
Minnesota	15,000	15,000	257,173.10			82,842.78	1,256.65
Mississippi	15,000	15,000	32,366.66	15,696.18	243.00	20,256.76	325.96
Missouri (College)	15,000	15,000	24,174.97	19,165.57	38,971.45	25,887.29	
Montana	15,000	15,000	110,517.60			27,342.42	
Nebraska	15,000	15,000	101,703.04	36,798.87		66,838.16	
Nevada	15,000	15,000		523.13		317.49	
New Hampshire	15,000	15,000		432.88		4,186.28	12,765.24
New Jersey (State)			89,392.30		48,780.94	33,813.17	
New Jersey (College)	15,000	15,000					
New Mexico	15,000	15,000	7,500.00	13,071.04		6,323.29	
New York (State) [4]	1,500	1,500	146,195.71	5,064.06			
New York (Cornell)	13,500	13,500	109,022.46		12,420.32	14,837.22	2,896.67
North Carolina	15,000	15,000	112,150.00	4,425.97		7,793.08	
North Dakota	15,000	15,000	69,432.81	24,411.93		58,186.53	4,850.00
Ohio	15,000	15,000	279,035.00	124,101.67		56,674.75	
Oklahoma	15,000	15,000	10,000.00	6,212.46		8,909.94	
Oregon	15,000	15,000	86,500.00	27,867.33		18,533.29	2,000.00
Pennsylvania	15,000	15,000	2,330.57				
Porto Rico [2]							50,000.00
Rhode Island	15,000	15,000		1,916.00			6,288.10
South Carolina	15,000	15,000	24,371.09	3,857.44		3,047.61	
South Dakota	15,000	15,000	13,500.00	11,426.94		4,449.09	11,932.89
Tennessee	15,000	15,000	51,939.73			15,974.91	
Texas	15,000	15,000	213,540.00	2,109.11		77,616.76	
Utah	15,000	15,000	48,084.61	2,867.19		19,454.13	
Vermont	15,000	15,000		1,142.46			
Virgin Islands [2]							15,000.00
Virginia	15,000	15,000	39,450.00	13,156.53		21,349.67	1,494.73
Washington	15,000	15,000	186,576.15	5,837.27		43,043.21	
West Virginia	15,000	15,000	67,500.00	2,025.09		21,939.87	
Wisconsin	15,000	15,000	162,527.00				
Wyoming	15,000	15,000		1,866.96		4,406.62	
Total	720,000	720,000	3,594,441.80	621,756.50	415,610.48	1,223,529.20	335,916.36

[1] Not including balances from Federal funds.
[2] Federal appropriation.

additions to equipment, 1920.

Total.	Additions to equipment.						
	Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.
$62,686.71	$100.00	$400.00	$600.00	$400.00	.....	$600.00	$2,100.00
75,000.00	.....	.....	.....	.....	.....	.....	.....
129,138.59	10,968.47	5.14	853.12	3,105.15	$6,522.90	639.16	22,093.94
56,396.00	.....	.....	851.31	1,463.69	37.00	27,648.00	30,000.00
276,651.26	13,554.89	664.49	1,590.16	4,106.85	10,903.17	2,014.03	32,833.59
164,862.02	.....	1,505.00	3,960.00	1,675.00	6,504.00	2,250.00	15,894.00
75,129.79	2.48	477.49	4.75	2,145.43	16.50	301.83	2,948.48
45,976.10	628.03	84.75	334.64	322.90	1,174.75	.....	2,545.07
64,306.91	.....	101.28	1,272.29	3,060.06	8,518.60	36.02	12,988.25
48,732.85	754.81	470.37	242.80	893.19	572.30	570.60	3,414.07
54,789.49	.....	331,60	772.19	1,356.70	1,442.22	6,821.89	10,724.60
20,000.00	.....	.....	.....	.....	.....	.....	.....
50,000.00	.....	.....	.....	.....	.....	.....	.....
60,813.12	3,400.00	50.00	1,400.00	350.00	2,300.00	825.00	8,325.00
324,353.72	1,139.35	.....	.....	.....	.....	21,000.80	22,140.15
506,736.00	9,334.30	1,065.35	307.82	812.24	31,307.98	393,563.99	436,391.68
315,480.33	.....	.....	.....	.....	.....	.....	.....
202,318.13	11,000.00	500.00	500.00	6,500.00	8,500.00	1,000.00	28,000.00
304,018.81	15,048.66	1,159.47	1,289.26	1,141.25	6,131.95	185.32	24,955.91
74,656.49	1,140.16	94.52	741.61	2,272.07	1,183.39	.....	5,431.75
81,755.30	.....	.....	.....	.....	.....	.....	.....
84,197.84	506.03	1,031.67	1,816.09	.....	744.71	.....	4,098.50
121,345.00	1,124.22	873.08	236.02	957.87	15.00	.....	3,206.19
169,700.73	.....	.....	.....	.....	.....	.....	.....
371,272.53	12,600.00	1,025.00	1,550.00	4,400.00	8,000.00	.....	27,575.00
98,888.56	4,225.00	13.50	20.00	5,257.00	21,311.40	4,362.13	35,189.03
138,199.28	2,705.64	39.72	1,753.50	237.61	4,727.65	870.52	10,334.64
167,860.02	.....	400.00	700.00	1,300.00	3,200.00	300.00	5,900.00
235,340.07	50,000.00	1,092.22	3,351.26	4,766.83	5,991.81	.....	65,202.12
30,840.62	1,097.07	63.13	169.67	377.85	1,556.51	436.17	3,700.40
47,384.40	324.60	208.37	216.57	408.31	.....	.....	1,157.85
171,986.41	.....	.....	.....	.....	.....	.....	.....
30,000.00	1,099.84	549.78	2,969.33	318.20	1,400.00	1,645.25	7,982.40
56,894.33	1,060.87	12.92	466.23	721.55	1,967.12	20.05	4,248.74
154,259.77	2,312.98	.....	.....	.....	.....	.....	2,312.98
166,176.67	5,831.18	488.85	1,156.83	1,913.19	61.50	6,625.31	16,076.86
154,369.05	1,614.60	592.34	.....	350.00	50.00	77.70	2,684.64
186,881.27	2,700.00	100.00	1,200.00	4,025.00	5,090.00	.....	13,115.00
489,811.42	2,862.47	2,255.49	979.10	495.00	3,175.70	11,642.84	21,410.60
55,122.40	.....	.....	.....	.....	600.00	.....	600.00
164,900.62	.....	58.54	1,764.16	9,887.75	970.00	2,310.48	14,990.93
32,330.57	.....	850.00	300.00	1,500.00	10,107.25	.....	12,757.25
50,000.00	1,495.77	112.54	13.50	294.30	275.00	118.95	2,310.06
38,204.10	52.62	163.23	14.31	84.35	104.40	6.85	425.76
61,276.14	12,000.00	400.00	1,000.00	15,000.00	11,000.00	100.00	39,500.00
71,308.92	1,900.00	200.00	750.00	1,500.00	380.00	.....	4,730.00
97,914.64	7,605.90	630.00	404.43	1,956.58	.....	571.60	11,168.51
323,265.87	14,630.85	1,627.50	3,994.25	7,789.72	2,800.00	6,952.63	37,794.95
100,405.93	100,000.00	366.41	1,092.07	1,116.46	6,581.38	695.85	109,852.17
31,142.46	.....	.....	.....	.....	.....	.....	.....
15,000.00	400.00	21.00	.....	277.66	28.85	.....	727.51
105,450.93	10,451.56	119.61	85.30	1,056.88	2,521.15	.....	14,234.80
265,456.63	82,340.73	283.95	1,274.12	8,513.49	8,410.50	2,371.92	103,194.71
121,464.96	.....	.....	.....	.....	.....	.....	.....
192,527.00	.....	.....	.....	.....	.....	.....	.....
36,273.58	8,287.62	545.03	243.77	749.59	3,874.66	517.71	14,218.38
7,631,254.34	396,300.70	21,033.34	42,240.46	104,769.72	190,059.35	497,082.60	1,251,486.17

[3] The resources from other than Federal funds are estimated.
[4] Including balances from previous year: $11.81 Hatch and $2.50 Adams.

TABLE 3.—*Expenditures from United States appropriations received*

Station.	Amount of appropriation.	Classified						
		Salaries.	Labor.	Publications.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.
Alabama	$15,000	$7,700.00	$3,261.91	$877.62	$481.51	$80.26	$38.50	$18.66
Arizona	15,000	12,798.39	280.35	50.00	233.59	30.48	64.00	99.33
Arkansas	15,000	8,338.37	963.90	891.76	213.87	130.68	169.41	112.78
California	15,000	15,000.00						
Colorado	15,000	12,073.62	1,009.95	84.50	62.76	31.79		91.08
Connecticut (State)	7,500	7,500.00						
Connecticut (Storrs)	7,500	7,500.00						
Delaware	15,000	9,010.08	1,786.55	2,235.30	817.72	81.24	89.72	19.50
Florida	15,000	8,330.00	1,759.49	1,297.85	828.00	102.29	280.08	13.23
Georgia	15,000	6,158.37	2,646.66	264.96	372.41	201.53	659.28	575.24
Idaho	15,000	10,507.87	2,010.26	238.97	72.75	43.87	42.50	287.66
Illinois	15,000	13,364.93	753.59	843.10	22.93			5.05
Indiana	15,000	12,912.83	1,743.55		3.09			
Iowa	15,000	8,241.25	276.00	776.12	386.93	135.23	125.72	15.08
Kansas	15,000	8,893.35	5,031.47	8.00	164.49	6.48		28.96
Kentucky	15,000	14,819.83		47.17				
Louisiana	15,000	6,998.25	4,011.39	1,105.36	239.80	79.82	359.51	7.50
Maine	15,000	8,068.25	1,012.75	195.04	608.96	148.11	598.29	4.12
Maryland	15,000	12,554.05	1,956.70	105.43	13.89	123.53	58.67	2.60
Massachusetts	15,000	14,081.50	918.50					
Michigan	15,000	14,985.45						
Minnesota	15,000	15,000.00						
Mississippi	15,000	8,926.81	2,402.76		19.91	125.60		
Missouri	15,000	9,107.63	1,498.09		206.76	299.89	79.59	195.70
Montana	15,000	9,085.02	1,701.15	1,969.41	416.98	44.85	87.83	514.65
Nebraska	15,000	6,449.97	3,864.46	2,034.68	55.95	7.80		64.20
Nevada	15,000	8,601.47	1,693.32	250.59	194.08	46.59	310.96	85.85
New Hampshire	15,000	8,937.05	1,392.84	1,778.99	573.00	236.95	606.27	37.96
New Jersey	15,000	9,599.98	1,875.07	203.68	265.02	23.43		305.76
New Mexico	15,000	5,899.24	4,019.68	1,368.73	84.70	143.06	139.82	140.50
New York (State)[1]	1,500	874.77	359.88		38.14	16.49		
New York (Cornell)	13,500	7,730.00	3,271.16		53.24	17.50	72.80	295.45
North Carolina	15,000	9,692.20	1,535.86		301.98	78.08		
North Dakota	15,000	14,837.51			6.09	13.21		2.46
Ohio	15,000	6,130.37	1,067.71		165.49	213.05	13.07	394.86
Oklahoma	15,000	9,286.81	1,066.20	677.88	492.85	12.79		570.02
Oregon	15,000	11,524.58	305.65	1,130.10	58.65	14.90		516.08
Pennsylvania	15,000	12,056.63	345.40	740.66	97.29	102.83		19.55
Rhode Island	15,000	7,614.38	3,931.64	289.99	187.37	255.26	363.83	93.20
South Carolina	15,000	7,558.36	3,514.53	280.76	584.37	91.91	38.65	16.65
South Dakota	15,000	8,119.26	2,366.10	1,980.55	79.91	152.27	3.60	5.80
Tennessee	15,000	9,896.73	1,004.56	88.29	423.46	97.88	591.64	10.80
Texas	15,000	11,120.92	2,041.61		180.36	43.66	22.00	204.16
Utah	15,000	9,775.35	2,511.56	65.44	48.25	33.78	109.03	80.75
Vermont	15,000	7,488.23	1,856.73	1,507.06	274.66	95.81	1,218.99	34.37
Virginia	15,000	9,629.79	3,179.89	2.50	262.51	101.12	539.69	2.60
Washington	15,000	9,485.57	3,353.03		32.10	5.32	12.15	7.44
West Virginia	15,000	11,386.94	2,126.35		50.10	66.36		146.19
Wisconsin	15,000	11,871.23	1,517.89	126.07	15.37	2.93	146.79	233.60
Wyoming	15,000	6,472.75	4,270.80	417.18	2.50	39.31	137.94	2.90
Total	720,000	484,025.94	87,556.94	23,933.74	9,693.79	3,577.94	6,980.33	5,262.29

[1] Including balance of $11.81.

under act of March 2, 1887 (Hatch Act), for the year ended June 30, 1920.

expenditures.

Seeds, plants, and sundry supplies.	Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$207.50	$378.51	$388.63	$397.65	$408.85	$622.61	$33.55	.....	$15.08	.....	$89.16	.....
398.40	51.05	.....	2.04	3.60	12.55	109.09	.....	793.45	.....	73.68	.....
947.92	51.12	1,283.00	.....	1,232.36	20.56	371.58	$37.00	235.69	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
171.54	.....	184.90	53.01	11.71	407.80	154.37	95.50	541.47	$26.00	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
349.81	6.95	.....	78.80	35.14	25.61	19.95	.....	347.13	16.50	50.00	.....
151.59	9.31	1,343.40	453.93	126.59	41.40	1.75	.....	121.94	20.00	119.15	.....
490.07	829.85	1,030.10	174.22	1,146.16	88.30	40.03	.....	269.82	20.00	33.00	.....
174.38	17.00	658.08	14.00	20.00	.....	168.56	.....	641.20	25.00	47.90	.....
.....	.....	.....	.....	.....	.....	.....	.....	10.40	.....	.....	.....
2.50	.....	223.00	.....	14.95	.40	.....	.....	98.88	.....	.80	.....
995.82	62.90	3,711.80	.....	104.71	8.21	.....	.....	160.23	.....	.....	.....
288.79	.....	28.20	.....	303.70	.....	6.00	.....	221.41	8.00	11.15	.....
.....	.....	.....	.....	.....	.....	.....	133.00	.....	.....	.....	.....
834.09	.....	431.09	2.77	355.92	8.75	.....	20.00	72.19	.....	473.56	.....
705.87	830.89	1,912.09	40.27	125.87	204.82	46.19	.....	339.62	.....	128.86	.....
91.26	.....	.....	81.67	12.20	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	14.55	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
166.87	.....	2,591.17	.....	.....	.....	.....	758.19	.....	.....	8.69	.....
536.02	.....	2,553.67	.....	33.13	83.03	90.00	85.15	103.56	.....	127.78	.....
230.22	.....	389.00	36.67	203.80	26.01	130.60	.....	147.25	.....	16.56	.....
148.13	.....	2,187.21	.....	.....	.....	.....	.....	187.60	.....	.....	.....
456.65	.....	217.58	51.97	847.09	33.75	10.70	399.48	1,109.94	.....	689.98	.....
254.85	28.00	136.08	208.37	324.71	10.45	40.51	.....	409.37	.....	24.60	.....
406.42	3.92	.....	52.15	66.15	180.77	40.60	.....	1,627.21	.....	349.84	.....
263.11	32.28	1,269.29	.....	459.92	11.90	8.25	975.00	18.27	.90	165.35	.....
20.70	.....	.....	.....	110.40	.....	.....	.....	10.51	.....	68.60	$0.51
1,106.93	157.19	.....	.....	245.50	55.10	143.21	.....	351.92	.....	.....	.....
.....	1,341.88	2,000.00	.....	.....	.....	.....	50.00	.....	.....	.....	.....
125.23	13.50	.....	.....	2.00	.....	.....	.....	.....	.....	.....	.....
579.82	634.28	2,170.62	750.00	2,283.33	.....	128.90	.....	.....	.....	513.50	.....
573.05	.....	1,368.80	101.75	407.67	76.75	49.23	114.50	133.43	.....	68.27	.....
41.00	.....	.....	10.54	135.00	559.10	93.56	.....	591.71	5.00	14.13	.....
621.40	587.14	.....	.....	156.18	4.75	.....	.....	268.17	.....	.....	.....
511.57	337.31	861.40	229.13	87.86	.....	8.76	17.85	18.68	1.40	190.37	.....
372.79	650.93	1,235.73	87.44	263.67	134.41	.....	.....	126.26	.....	43.54	.....
450.36	.....	856.55	48.88	454.83	30.00	205.38	.....	232.26	.....	14.25	.....
556.63	30.00	81.08	315.95	733.25	494.40	.....	.....	110.19	.....	565.14	.....
162.10	.....	90.65	41.50	605.65	.....	91.48	295.00	.....	20.00	80.91	.....
435.46	.....	967.19	241.49	123.43	225.22	3.50	.....	176.25	15.00	188.30	.....
508.21	31.98	441.18	263.50	8.66	268.24	5.00	.....	398.74	.....	598.64	.....
376.21	336.63	.....	15.76	257.98	7.48	.....	.....	246.40	20.00	21.44	.....
525.36	106.49	13.40	.....	156.47	326.15	2.50	.....	966.52	.....	7.50	.....
91.71	272.10	.....	.....	13.52	.....	68.43	.....	778.30	.....	.....	.....
172.85	99.88	.....	.....	140.08	59.06	507.84	.....	106.41	.....	.....	.....
234.77	.....	2,875.21	.....	132.78	7.25	.....	.....	110.48	.....	296.13	.....
15,737.96	6,901.09	33,500.10	3,753.46	12,109.82	4,049.38	2,579.52	2,980.67	12,097.94	117.80	5,080.78	0.51

TABLE 4.—*Expenditures from United States appropriations received under the*

Station.	Amount of appropriation.	Classified						
		Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.	Seeds, plants, and sundry supplies.
Alabama	$15,000	$10,433.80	$1,594.14	$57.82	$186.95	$94.10	$375.70	$84.93
Arizona	15,000	11,505.66	296.35	150.79	47.87	.....	275.38	159.36
Arkansas	15,000	9,408.80	1,780.56	44.86	117.73	141.70	495.79	522.05
California	15,000	8,461.62	2,018.44	28.11	17.22	2.10	549.34	557.74
Colorado	15,000	12,304.84	628.37	56.72	5.35	.....	185.80	98.64
Connecticut (State)	7,500	5,985.82	276.97	58.90	40.63	350.94	138.07	192.73
Connecticut (Storrs)	7,500	7,500.00	.....	.....	.....	.....	.....	.....
Delaware	15,000	10,873.76	484.82	3.90	12.14	121.07	1,668.58	42.58
Florida	15,000	9,441.09	1,697.91	95.59	99.06	60.94	418.70	250.97
Georgia	15,000	9,589.58	975.69	23.58	147.16	206.46	324.97	212.74
Idaho	15,000	11,196.21	1,553.76	6.00	99.16	1.25	608.64	313.29
Illinois	15,000	13,572.70	754.00	7.93	4.62	.....	177.26	.....
Indiana	15,000	11,058.38	1,114.02	89.84	.....	.....	234.20	271.28
Iowa	15,000	7,961.43	2,877.37	272.44	6.72	348.00	1,486.40	727.23
Kansas	15,000	9,108.33	3,830.57	13.26	4.05	22.75	730.62	310.07
Kentucky	15,000	13,138.35	330.60	30.30	6.04	41.17	62.86	103.85
Louisiana	15,000	11,173.15	400.00	39.39	70.50	301.73	1,010.26	153.08
Maine	15,000	9,999.96	2,032.67	61.25	116.28	289.18	23.58	223.44
Maryland	15,000	11,712.02	329.32	21.97	.....	.....	655.23	404.20
Massachusetts	15,000	14,448.31	272.00	.....	.....	.....	4.58	58.89
Michigan	15,000	15,000	.....	.....	.....	.....	.....	.....
Minnesota	15,000	15,000	.....	.....	.....	.....	.....	.....
Mississippi	15,000	10,257.40	2,959.81	20.09	40.77	266.07	.....	247.10
Missouri	15,000	6,292.38	1,990.40	32.19	229.25	117.44	498.50	373.08
Montana	15,000	12,881.44	500.35	40.86	48.83	16.42	679.37	66.24
Nebraska	15,000	10,799.96	1,387.74	.....	24.84	.....	184.79	543.85
Nevada	15,000	9,296.45	2,154.02	2.65	44.95	.....	281.66	171.43
New Hampshire	15,000	11,367.41	2,033.10	26.82	22.37	4.91	143.35	396.93
New Jersey	15,000	10,836.08	973.42	65.32	38.95	10.55	569.51	454.56
New Mexico	15,000	9,801.01	2,757.99	12.07	115.75	408.86	547.63	469.03
New York (State) [1]	1,500	1,356.07	.....	.....	.....	.....	56.65	.....
New York (Cornell)	13,500	12,100.00	415.24	101.38	.....	.....	236.58	200.54
North Carolina	15,000	15,00.00	.....	.....	.....	.....	.....	.....
North Dakota	15,000	11,580.69	175.35	.....	13.87	.....	368.05	51.82
Ohio	15,000	8,878.13	2,496.85	26.89	31.79	.....	1,124.05	162.56
Oklahoma	15,000	11,104.15	1,952.79	59.28	4.09	19.68	93.62	190.22
Oregon	15,000	13,850.00	54.28	5.00	25.55	22.26	746.94	147.02
Pennsylvania	15,000	11,867.86	674.49	38.06	22.27	.....	286.37	208.87
Rhode Island	15,000	8,819.03	3,471.95	52.91	5.62	254.00	302.84	127.52
South Carolina	15,000	11,457.03	1,273.31	16.71	57.62	15.28	574.69	246.26
South Dakota	15,000	9,260.87	2,838.41	1.65	78.72	.....	155.37	625.44
Tennessee	15,000	11,739.54	647.10	45.35	120.23	323.26	960.70	129.46
Texas	15,000	9,482.16	2,117.49	53.27	143.78	.....	1,453.68	340.73
Utah	15,000	9,775.60	3,858.71	1.64	108.98	39.43	368.41	358.64
Vermont	15,000	10,069.82	1,583.86	39.12	33.18	5.99	74.99	210.03
Virginia	15,000	10,437.50	2,574.34	.....	71.89	1.32	295.53	231.26
Washington	15,000	11,606.08	1,870.90	13.47	.....	.....	311.55	340.98
West Virginia	15,000	11,493.35	674.32	.....	.66	45.15	798.59	324.62
Wisconsin	15,000	8,967.50	3,346.88	5.75	4.04	132.36	111.47	400.17
Wyoming	15,000	9,825.52	1,640.49	6.78	79.20	125.74	1,055.82	98.68
Total	720,000	529,076.84	69,671.06	1,729.91	2,348.68	3,790.11	21,706.67	11,804.11

[1] Including balance of $2.50.

act of March 16, 1906 (Adams Act), for the year ended June 30, 1920.

expenditures.

Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$174.15	$779.05	$42.25	$43.97	$56.68	$641.44	.....	$351.22	.....	$83.80	.....
.....	.....	2.10	226.99	135.55	736.53	.....	750.80	$1.40	711.22	.....
288.03	629.66	.....	231.33	312.03	479.73	.....	547.73	.....	.....	.....
.....	325.44	20.46	357.73	390.64	200.20	$300.00	1,510.68	.....	260.28	.....
11.69	7.30	.....	.....	745.55	420.19	.....	225.00	.....	310.55	.....
113.04	204.46	.....	26.67	4.20	1.00	.....	104.07	2.50	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
144.10	.....	22.44	45.30	.....	1,252.34	.....	228.96	.....	100.00	$0.01
584.71	.....	14.57	152.81	162.25	241.05	.....	1,542.39	.....	237.96	.....
.....	2,511.65	54.75	74.65	.....	14.15	658.72	204.65	.....	1.25	.....
.....	127.50	.....	154.78	.....	313.70	100.00	328.81	.....	196.90	.....
.....	228.46	.....	47.79	66.39	.....	39.00	101.85	.....	.....	.....
144.44	194.96	215.13	329.60	83.48	307.82	706.84	250.01	.....	.....	.....
30.40	432.40	.....	187.49	6.95	478.62	10.25	30.55	.....	143.75	.....
.65	308.29	.....	205.04	6.77	21.25	96.50	35.00	.....	306.85	.....
.....	491.45	13.23	28.60	.....	465.22	229.00	59.33	.....	.....	.....
.....	225.63	83.25	2.75	92.25	741.61	10.50	674.65	.....	21.25	.....
.....	1,628.99	136.65	.....	121.75	26.96	.....	275.81	.....	63.48	.....
.....	.....	6.75	269.54	415.04	1,019.09	.....	11.51	.75	154.58	.....
216.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	265.00	25.90	73.50	.....	742.04	.....	102.32	.....	.....	.....
28.00	3,861.01	6.00	2.25	.....	1,391.31	4.50	78.79	.....	94.90	.....
.....	.....	41.95	8.35	33.40	201.12	.....	481.67	.....	.....	.....
.....	494.96	63.00	1.37	49.00	756.37	366.77	327.35	.....	.....	.....
.....	1,467.79	8.00	43.00	23.60	31.67	1,167.38	307.40	.....	.....	.....
105.00	164.88	.....	83.60	35.00	176.06	.....	140.57	.....	300.00	.....
3.13	360.00	117.70	252.05	35.26	112.00	250.00	.....	4.75	750.00	166.72
4.67	56.71	4.51	133.15	8.15	454.23	50.00	.....	.....	176.24	.....
.....	.....	.....	.....	.....	52.50	.....	.....	.....	.....	34.78
.....	.....	.....	203.83	.....	242.43	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	787.60	.....	568.02	.....	.....	1,454.60	.....	.....	.....	.....
.....	245.88	588.03	451.84	.....	745.23	213.92	.....	.....	34.83	.....
72.50	526.33	61.00	67.82	110.74	313.09	355.78	68.91	.....	.....	.....
.....	.....	.....	.....	.....	134.95	.....	.....	.....	14.00	.....
.....	.....	134.69	5.20	.....	945.25	.....	66.94	.....	750.00	.....
.....	1,730.69	2.80	66.08	.....	9.66	88.85	.....	3.15	64.90	.....
364.32	110.40	37.44	79.50	29.86	721.38	.....	3.50	.....	12.70	.....
28.48	549.38	78.17	28.75	73.00	655.30	244.00	382.46	.....	.....	.....
.....	.....	114.07	118.25	60.10	404.43	.....	127.13	.....	210.38	.....
.....	17.55	15.25	215.92	201.99	480.02	99.25	39.63	.....	339.28	.....
.....	.....	.....	64.43	17.50	261.17	.....	145.49	.....	.....	.....
7.85	597.79	11.00	1.75	19.33	1,042.46	165.00	387.83	.....	750.00	.....
40.10	960.99	.....	41.15	2.20	6.65	.....	212.07	.....	125.00	.....
.....	.....	.....	2.70	69.50	579.62	.....	205.20	.....	.....	.....
54.80	198.45	.....	140.60	85.75	800.86	90.00	292.85	.....	.....	.....
1.73	1,777.72	4.15	152.39	.70	30.00	.....	62.44	.....	2.70	.....
.....	1,299.32	45.03	357.05	.....	243.77	111.25	106.89	.....	4.55	.....
2,418.01	23,567.69	1,970.27	5,547.59	3,454.61	18,894.47	6,812.11	10,772.46	12.55	6,221.35	201.51

Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, and March 16, 1906.

State or Territory.	Hatch Act.		Adams Act.	
	1888–1919	1920	1906–1919	1920
Alabama	$478,956.42	$15,000.00	$176,619.89	$15,000.00
Arizona	444,803.10	15,000.00	179,955.61	15,000.00
Arkansas	478,139.12	15,000.00	179,900.60	15,000.00
California	480,000.00	15,000.00	179,926.84	15,000.00
Colorado	479,718.82	15,000.00	178,638.93	15,000.00
Connecticut	480,000.00	15,000.00	180,000.00	15,000.00
Dakota Territory	56,250.00			
Delaware	478,382.87	15,000.00	175,475.12	15,000.00
Florida	479,966.06	15,000.00	179,996.06	15,000.00
Georgia	475,593.43	15,000.00	167,092.87	15,000.00
Idaho	404,324.13	15,000.00	175,842.22	15,000.00
Illinois	479,564.95	15,000.00	179,851.62	15,000.00
Indiana	479,901.19	15,000.00	180,000.00	15,000.00
Iowa	480,000.00	15,000.00	180,000.00	15,000.00
Kansas	479,995.00	15,000.00	180,000.00	15,000.00
Kentucky	479,996.57	15,000.00	180,000.00	15,000.00
Louisiana	480,000.00	15,000.00	180,000.00	15,000.00
Maine	479,999.62	15,000.00	180,000.00	15,000.00
Maryland	479,967.40	15,000.00	179,236.48	15,000.00
Massachusetts	479,617.70	15,000.00	180,000.00	15,000.00
Michigan	479,676.10	15,000.00	176,341.20	15,000.00
Minnesota	479,917.78	15,000.00	179,345.00	15,000.00
Mississippi	480,000.00	15,000.00	180,000.00	15,000.00
Missouri	475,097.24	15,000.00	179,999.90	15,000.00
Montana	390,000.00	15,000.00	177,417.04	15,000.00
Nebraska	479,932.16	15,000.00	180,000.00	15,000.00
Nevada	479,214.32	15,000.00	178,180.28	15,000.00
New Hampshire	480,000.00	15,000.00	180,000.00	15,000.00
New Jersey	479,949.97	15,000.00	179,558.78	15,000.00
New Mexico	444,509.05	15,000.00	180,000.00	15,000.00
New York	479,777.75	14,988.19	179,500.53	14,997.50
North Carolina	480,000.00	15,000.00	165,000.00	15,000.00
North Dakota	421,502.26	15,000.00	179,638.85	15,000.00
Ohio	480,000.00	15,000.00	178,514.02	15,000.00
Oklahoma	404,568.96	15,000.00	161,360.56	15,000.00
Oregon	465,156.64	15,000.00	175,000.00	15,000.00
Pennsylvania	479,967.43	15,000.00	179,995.41	15,000.00
Rhode Island	480,000.00	15,000.00	177,464.20	15,000.00
South Carolina	479,542.15	15,000.00	178,460.12	15,000.00
South Dakota	423,250.00	15,000.00	175,000.00	15,000.00
Tennessee	480,000.00	15,000.00	180,000.00	15,000.00
Texas	480,000.00	15,000.00	177,592.26	15,000.00
Utah	345,000.00	15,000.00	179,821.94	15,000.00
Vermont	480,000.00	15,000.00	180,000.00	15,000.00
Virginia	477,824.12	15,000.00	179,949.01	15,000.00
Washington	417,102.65	15,000.00	176,080.11	15,000.00
West Virginia	479,968.71	15,000.00	177,859.12	15,000.00
Wisconsin	480,000.00	15,000.00	180,000.00	15,000.00
Wyoming	465,000.00	15,000.00	180,000.00	15,000.00
Total	22,422,133.67	719,988.19	8,554,613.97	719,997.50